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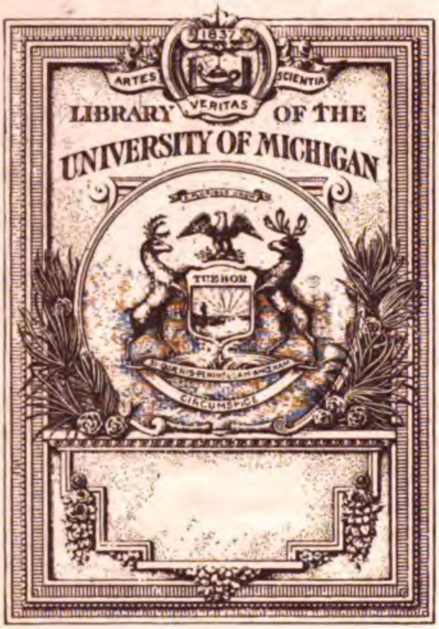

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VOLUME 50
1919

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1918

The Journal U. S. Artillery announces the following for its annual competition.

PRIZES

One hundred and fifty dollars will be given for the best essay and one hundred dollars for the second best essay submitted on any Coast or Heavy Artillery subjects.

CONDITIONS OF THE COMPETITION

(a) Competition will be open to all readers of the Journal.

(b) Award will be made by a committee of award, consisting of three persons, to be nominated by the Coast Artillery School Board. If no essay submitted seems to the committee worthy of a prize, none will be awarded. Honorable mention may be made of any essay submitted which seems to the committee worthy thereof, but to which a prize is not awarded.

(c) All essays entered in competition will become the property of the Journal of the United States Artillery. These will be published, if approved by the Coast Artillery School Board.

(d) Copy must be typewritten, with lines double spaced, on one side of the paper only, and must be submitted in triplicate. If illustrations are included, one of the three copies thereof must be in the form of drawings, tracings, or photographs (not blue-prints nor brown-prints).

(e) Copy must contain nothing to indicate its authorship, must be signed with a *nom de plume*, and must be accompanied by a sealed envelope containing this *nom de plume* and the name of the writer. This envelope will remain in the hands of the Editor of the Journal and, after award has been made by the Committee, will be opened in the presence of the Coast Artillery School Board.

(f) Copy must be received on, or before, December 31, 1918. It must be addressed Journal U. S. Artillery ana the envelope must bear the notation, "Essay Competition."

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Frontispiece

THE COAST ARTILLERY SCHOOL BUILDING AT FORT MONROE

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JOURNAL
OF THE
UNITED STATES ARTILLERY

VOL. 50, No. 1. JANUARY-FEBRUARY, 1919 WHOLE No. 151

Coast Artillery Training in the War

OFFICERS' DEPARTMENT

By 2nd Lieutenant Geddes Smith, C. A.

"The rôle assigned to the Coast Artillery of the United States in the European War is that of handling the railroad artillery and a part of the heavy artillery—These mounts are rather complicated and take some time to construct. We do not, however, propose to lose any time in waiting for such construction. We propose to use whatever guns we can get, big or little, and. . . improvise fire control apparatus, conforming in principle to the standard fire control for use in the field, thus simulating the guns. . . and methods that we shall later have to use."

This statement of policy made at the beginning of the first War Training Camp at Fort Monroe by the first Commandant, Colonel S. M. Foote, sounds the keynote for the first period of the officer training which has fallen to Fort Monroe, and the Coast Artillery School as its special war task and which has resulted in transforming the Fort and turning the school into something quite unlike anything in its long past.

The Coast Artillery School was going steadfastly about its business when the United States entered the Great War. Fifty students were taking the regular course. The Commandant, in the report for 1916, had looked forward to the

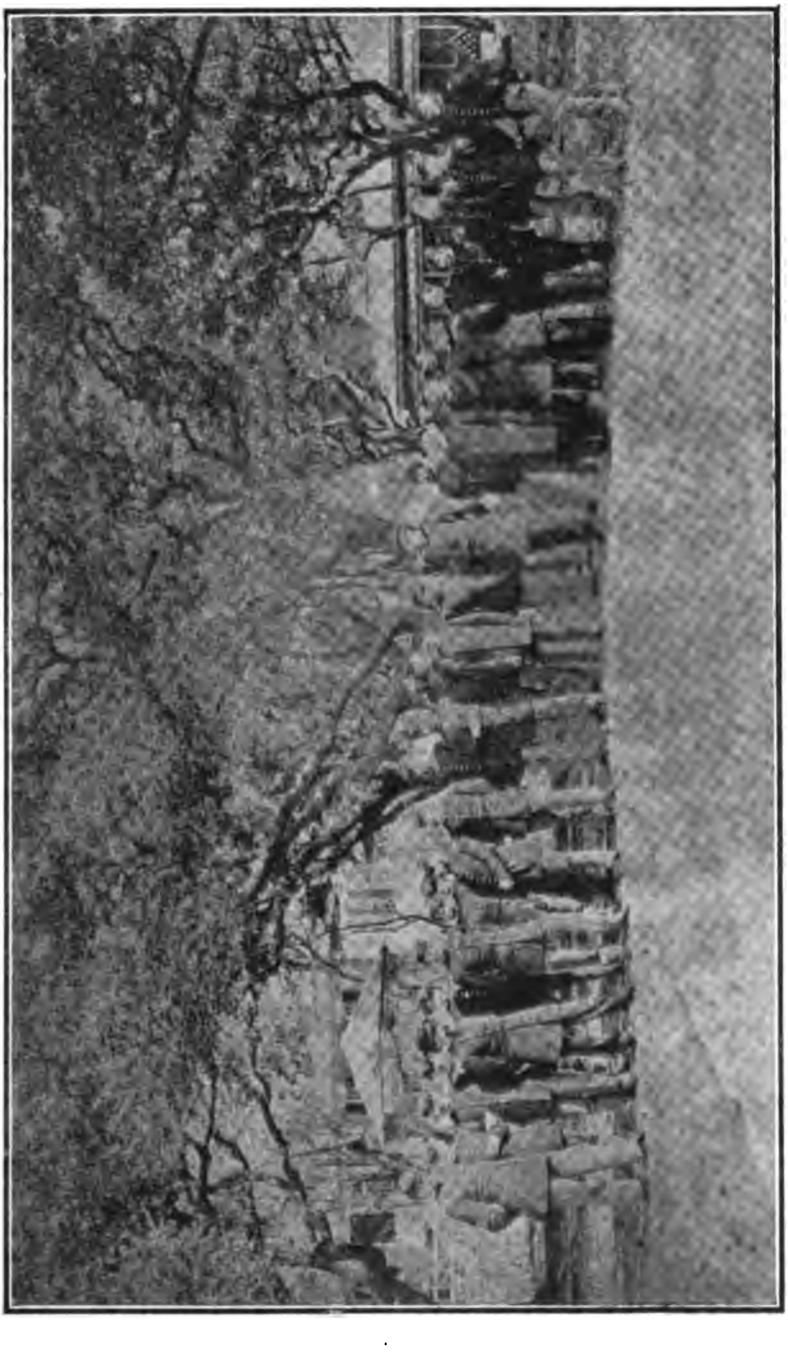
---

Note. This article was prepared under the supervision of Major Fred Engelhardt, C. A., Inspector of truction, and with the special assistance of Lieut. Col. Abney Payne, C. A., Director of Instruction. Major liam C. Foote, C. A., Senior Instructor, Materiel, Major E. A Ziegler, C. A., Senior Instructor, Orientation, tain Earl W. Thomson, C. A., Assistant Senior Instructor, Gunnery and Major Arthur H. Lloyd, Engineer ps, Construction Quartermaster.

addition of an anti-aircraft gun to the equipment of the School, and instruction in its technique, and in the "use of mobile heavy and light guns, mounted on railway cars and motor trucks" to the curriculum. But that was only the faintest suggestion of the transformation that was in store.

During the entire history of successive schools at Fort Monroe the tendency had been to confine instruction more and more strictly to the seacoast problem as distinguished from the general field of artillery. In 1906 the regulations for the School confined its work to coast artillery technique; in the following year the formal separation of the Coast Artillery Corps and the Field Artillery emphasized the differentiation in function. Yet a year of war was to see the gradual submergence of the Coast Artillery problem, for the time being, in the new work thrust upon the Corps by the emergency, until seacoast gunnery became a minor part of a new course of instruction which was focussed very definitely upon the battlefields of France. It was not easy for the officers and instructors of the Coast Artillery Corps to execute this about face; the history of the Coast Artillery Training Camps during their first phase is the story of gradual abandonment of the methods associated with the seacoast batteries, which it was believed needed but slight modification to serve the purposes of the work in France.

In considering the history of the Coast Artillery School and the Coast Artillery Training Camp during the war, it is therefore convenient to divide it broadly into three parts. The first begins with the initial training camps for civilians in which the Plattsburg idea was applied to the problem of rapidly producing trained officers for the new armies, and includes the first, second, and most of the third Coast Artillery Training Camps. It ends near the conclusion of the third camp, with the return of Lieut.-Colonel Sunderland and Major Welshimer from the Heavy Artillery School in France and the consequent changes in organization and instruction which turned the camp from a Coast Artillery School into a Heavy Artillery School. The second period, in which the curriculum was definitely linked up with French conditions, includes the end of the third camp and more particularly the fourth and fifth. The third period begins with the organization of the Training Center under the command of Brigadier General F. K. Fergusson, and the inauguration of the Continuous Camp. These changes were principally administrative and quantitative, but they in-



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YE GOOD OLD DAYS
CLASS OF 1869 OF THE ARTILLERY SCHOOL AT FORT MONROE

volved so great a development and extension of the work of the school that they may fairly be said to begin a new period in its history. This stage ends, of course, with the signing of the armistice and the gradual abandonment of the machine which had been so enthusiastically constructed. It is the purpose of this article to trace the development of the Coast Artillery School and its expansion into the Coast Artillery Training Center, in the training of new officers. The detailed development of the work in each of the departments can be described after tracing the broader history of the camp.

I.

THE FIRST CIVILIAN CAMPS

Less than six weeks after the declaration of war, the first civilian camps for reserve officers and candidates for appointment as such were opened. The story of these improvised schools which began their three months' course on May 14 had been told many times. The unfinished barracks, the rigors of a cold, late spring in the northern camps, the eager receptiveness of thousands of highly picked students—these memories are still vivid among those who have followed the fortunes of the greatest army the United States has ever produced. It is necessary here only to trace the relations between them and the Coast Artillery.

The fundamental plan of instruction in these camps was to give all officer candidates, regardless of the arm of the service for which they were destined, the same basic training in infantry and army administration during a "first period" lasting from May 15 to June 16, and then to diversify the training to prepare qualified candidates for their special duties with infantry, cavalry, field artillery, coast artillery, and the engineer corps. Special Regulations No. 49, published under date of May 5, 1917 to govern the conduct of the First Camp, specified that:

"During the first period a number of candidates will be designated from the First, Second, Fifth, Sixth, Seventh, Twelfth, Fifteenth, and Sixteenth Provisional Training Regiments for further training in Coast Artillery Service during the second period. The number to be designated and all arrangements for their further training will be determined by the Chief of Coast Artillery."

Subsequent instructions from the War Department modified this arrangement by providing that a detachment of Coast Artillery candidates should be withdrawn from each of the sixteen training regiments after the first period. A letter from the Adjutant General of the Army, June 1, 1917 is as follows:

"1. To conform to the changes in organization, armament and training found necessary with reference to the National Army to be raised under the Act of Congress approved May 18, 1917, the instructions heretofore issued from this office relative to the organization of provisional training regiments at training camps are modified as follows:

3-INCH ANTI-AIRCRAFT GUN 2205

"Before or at the conclusion of the 'First Period' (June 15) the reserve officers and candidates of each training regiment who are to be retained for 'Second Period' instruction will be assigned finally to organizations as follows:

* * * * * *

"(e) Coast Artillery contigent. See Paragraph 4.

"4. Contingents consisting of reserve officers of Coast Artillery and candidates for commissions in that arm will be selected in time to be sent to new camps as indicated below, leaving their camps June 16, or the evening of June 15, 1917.

From Training Regiment	Number of Contingent	From	To Camp at
1st	100	Plattsburg Barracks	Fort Monroe, Va.
2nd	100	Plattsburg Barracks	"
3rd	50	Madison Barracks	"
4th	50	Fort Niagara	"
5th	100	Fort Myer	"
6th	100	Fort Oglethorpe	"
7th	100	Fort McPherson	"
8th	50	Fort Benjamin Harrison	"
9th	50	Fort Benjamin Harrison	"
10th	50	Fort Sheridan	"
11th	50	Fort Sheridan	"
12th	100	Fort Logan H. Roots	"
13th	50	Fort Snelling	"
14th	50	Fort Riley	"
15th	100	Leon Springs	"
16th	200	Presidio San Francisco	Ft. Winfield Scott

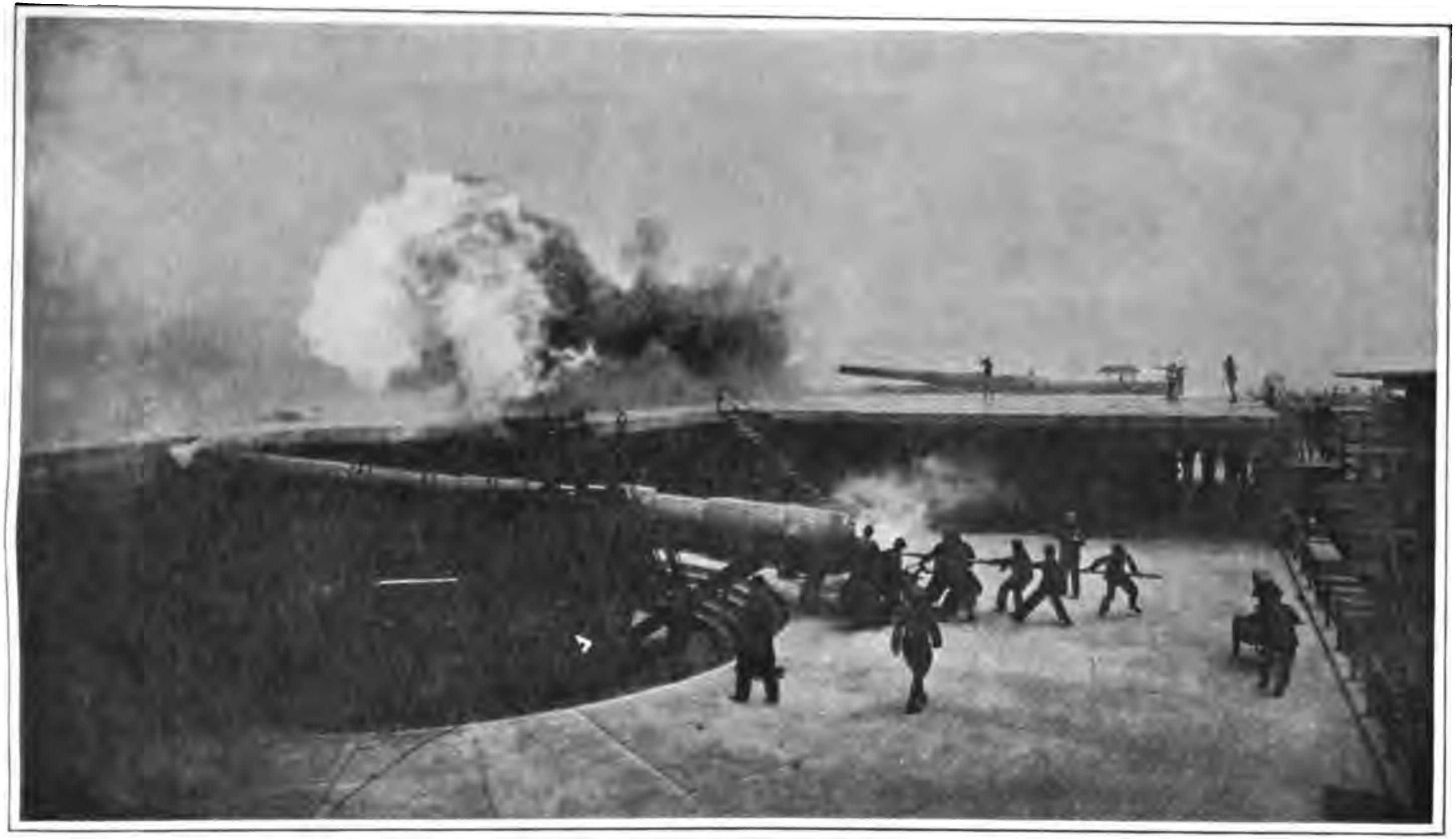
* * *

"Coast Artillery officers of the Regular Army heretofore detailed as instructors at training camps from which any of the above contingents are drawn will accompany such contingents and will report to the commanding officer at their destination for temporary duty as instructors.

"The Commanding Officer of the Coast Defenses of Chesapeake Bay will be the Commanding Officer of the Coast Artillery training camp hereby established at Fort Monroe. The Commanding Officer of the Coast Defenses of San Francisco will be the Commanding Officer of the Coast Artillery Training camp hereby established at Fort Winfield Scott. Each commanding officer will appoint a suitable staff and corps of instructors. The duties of Commanding officer, staff officers, and instructors will be in all respects the same as prescribed for commanding officers or corresponding officers of the present training camps.

* * *

"In selecting contingents to be transferred to Coast Artillery training camps, commanding officers will take into consideration the fact that the Coast Artillery requires reserve officers for seacoast guns, mortars, and mines; also railroad artillery and heavy seige artillery to be organized as tactical units for use in the European theater of war."



TARGET PRACTICE AT A 12-INCH BATTERY. ALMOST READY FOR THE NEXT ROUND

WHAT WAS THE COAST ARTILLERY TO DO?

The decision to use the coast artillery mobile batteries in France, indicated in the final paragraph just quoted, had not been arrived at immediately upon the declaration of war. There was a period of considerable doubt as to the rôle of the Corps in the war, and it is said that the emphatic advice of the French Commission played a large part in determining the policy of the War Department in this particular. A letter dated so late as May 1, 1917, from the office of the Chief of Coast Artillery to the Commandant of the Training Camp, read as follows:

"The course prescribed for the candidates for temporary commissions and the course for those who are candidates for commissions in the Officers' Reserve Corps should be such as to train them for their general duties as Coast Artillery officers. That would include not only the manning of the seacoast guns now emplaced, but also any *railroad mounts which might be required in the future.*

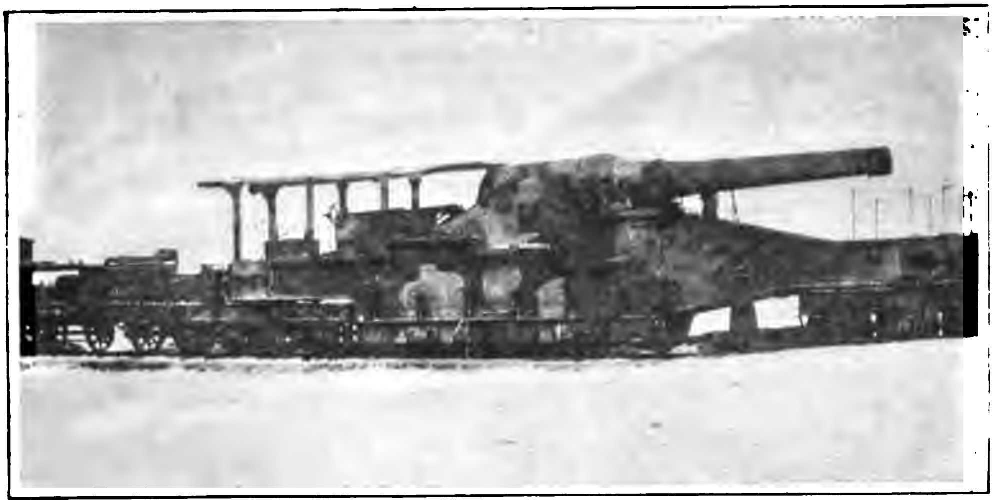
"It is impossible to state at this time what action the Secretary will take with reference to the sending of Coast Artillery troops as such overseas. There is little doubt, however, that the Coast Artillery officers and enlisted men may be called upon for any duties for which the United States needs them, and *I believe that a good proportion of the Coast Artillery officers will be detached for service with field artillery or that the Coast Artillery units may be required for manning some of the heavy artillery for use in Europe.* It is very difficult to give any definite information at the present time, because policies are changing frequently during the process of forming the permanent policies."

Though the decision to use the Coast Artillery to man heavy artillery in France was made before June, the definite statement of the policy to be followed came later. It was made in the form of an indorsement from the War Department, A. G. O., July 14, 1917, to the Chief of Coast Artillery. In part it follows:

"1. During the present war all oversea fortifications and all mine defenses in the United States will be manned by the regular coast artillery.

"2. The National Guard coast artillery, when drafted into the Service of the United States, will be employed for the present, in manning the gun defenses of the fortifications within the United States.

"3. The remaining enlisted personnel of the regular coast artillery (deducting personnel specified in paragraph 1 above, and that for the railway brigade already authorized), together with the necessary number of officers, will be organized into provisional regiments of coast artillery for service as field artillery during the war, and as far as practicable the regiments will be equipped with guns and howitzers of 6-inch and larger calibers, heavy railway artillery, anti-aircraft guns, etc., and employed in supplementing the regular field artillery.



32 cm. Railway gun Manned by the Coast Artillery 2207

"4. The necessary steps will be taken to organize 9 provisional regiments of coast artillery for service as field artillery, as soon as the new tables of organization, now being prepared, are issued and the Chief of Coast Artillery will submit complete plans, including lists of personnel, etc., for these organizations.

"5. Until better material is available, such land defense cannon now assigned to coast defense commands, will be utilized in connection with the training of these provisional regiments and will be sufficient for the purpose.

By Order of the Secretary of War:

J. T. DEAN,
Adjutant General."

THE PRELIMINARY CAMPS

In one respect, the task of the first camp was simpler than that of some of its successors. All its students had been through five weeks of the intensive infantry drill of the general training camps before turning to artillery and there were no recruits, raw from civil life, to learn trying foot movements and ballistics all at the same time.

At the camps these men had been put through rigorous physical drill, instruction in the School of the Soldier, the Squad, Company, and the Battalion, and a course in semaphore and wigwag signalling. They had handled the bayonet in drills so realistic that many men were badly shaken psychologically. They were acquainted with interior guard duty and small arms firing practice. They had marched miles, in both light and heavy marching order. And they had been instructed in Army Regulations, Field Service Regulations, Studies in Minor Tactics, and Small Problems for Infantry. The theoretical instruction, to be sure, was of the informal and not very conclusive sort that is staged in barracks, sometimes with the instructor backed against a wood stove to keep from an icy death while the class huddled as closely around him as possible. It could hardly compare in thoroughness with the organized work of the classroom, which Fort Monroe was later to introduce in a systematic way which made it distinctive among the training camps. But it did lay the foundation for further teaching, and brought to the artillery school men who knew already the fundamentals of soldiering.

During the first weeks of June the men in the camps were divided between the various arms of the service. In picking candidates for Coast Artillery some emphasis was laid on mathematical preparation, but the primary importance of this qualification was not yet fully appreciated, since in the existing technique of the Coast Artillery mechanical computing devices were firmly established. Men were allowed to state their preference, and while those of engineering experience were guided whenever possible into the Corps, no doubt the man's own choice was quite as decisive, in many cases, as anything else. And since nobody knew very definitly what the Coast Artillery was about, it can safely be said that any high degree of selection was impossible. But the rigorous elimination of prospective candidates which had preceded the opening of the camps, and the high average of the survivors made this rather approximate method of choosing Coast Artillery officers more promising than it would have been at a later date, when officer material had been largely combed out by repeated levies.

The First Camp at Fort Monroe

Twelve hundred candidates were assembled at Fort Monroe on June 18, 1917, to begin the first war course in Coast Artillery. Two hundred others from the Presidio of San Francisco were sent to Fort Winfield Scott, where a separate training center was maintained during the first and second camps. This scheme proved unsatisfactory, and after the end of 1917 all officer candidates in the Coast Artillery were concentrated at Fort Monroe. The Camp at Fort Monroe, in accordance with the instructions of the War Department, was commanded by Colonel S. M. Foote, Commanding Officer of the Coast Defenses of Chesapeake Bay.

The accomodations of the Coast Artillery School were of course far too scanty to take care of this tremendous influx. The garrison of Fort Monroe, much reduced by the organization of a provisional brigade for overseas service and the sending of two companies to guard the White House, was moved out of its barracks in the Old Fort and sent into tents on the beach. The candidates moved in, and the old squadrooms have not ceased from that time to this to resound with the picturesque waking curses of men who lived on edge for three months.

Old Point was as yet innocent of the clustering shacks which have since transformed its sober dignity into a cross between a mill-town and a winter resort. The laboratories and classrooms of the Coast Artillery School were available for teaching, and the basement-rooms of one of the barracks, since appropriated by the surveyors of the Orientation Department, were pressed into service. The weather was favorable, too, for some outdoor instruction, and it is said that a certain group found great pleasure and profit by listening attentively while an instructor read aloud from *Over the Top*.

The instructors of the First Camp were Regular officers, assisted by sergeants and master gunners. Only the heads of departments were attached to the Coast Artillery School.

The work in the first camp was divided broadly into three periods of nine working days each, followed by three or four days of lectures on a variety of subjects, and then by a ten-day period of target practice. "Coast Artillery and Mobile

Gunnery and Ammunition" ran through the three nine-day periods, but the other subjects were given to sections in rotation. One group began with nine days of seacoast mortars, another with seacoast guns, and another with field artillery which was based entirely on the three-inch gun, in which the candidates were thoroughly drilled. Three minor courses, in "Artillery Defense," which was almost entirely the War Game; Map Reading and Field Fortification; and Minor Tactics, in which a certain amount of information from the front in France was incorporated, accompanied the courses at the emplacements. The sections took these, also, in rotation, so that the sequence of work for one section would be quite different from that of another. After these three nine-day periods, and in fact before the third was completed (since it proved necessary to shorten the course by four or five days) there came a rather miscellaneous collection of minature courses in mechanical maneuvers, telephone and signalling, gas engines, courts-martial, and paper work.

One company was sent for part of its mechanical maneuvers to a twelve-inch gun lying in a cradle of skids back of Battery Parrot. One after another, the section-leaders were given a chance to show what they could do in moving that gun a few inches out of its cradle. One after another they tackled the problem, lining their sections up on the stout rope that was provided; one after another they failed to do more than rock the gun back and forth a little. Then the instructor took charge, with some annoyance in his manner, and himself lined up a section, applying the rope according to his own ideas, and giving the command "Heave" with much authority. Unfortunately the rope promptly broke. The demonstration was tactfully changed into a general tug of war, and section pulled section till the period was over.

The embryonic course in administration consisted of a very few lectures. There was only the most casual exhibition of army forms, and no examination. Part of the time was devoted to instruction in the proper method of fitting recruits with shoes, part to advice on what sort of equipment officers should buy—which advice proved wholly disastrous to those who accepted it.

Target Practice

There may have been some uncertainty as to the way in which the Coast Artillery would handle its task in France, and the predisposition of the School in favor of the Coast Artillery methods of mechanical computation may have hindered the adaptation of instruction to Western Front conditions, but the enthusiastic way in which the target practice of the first camp was made to simulate firing in France was ample evidence of the determination of the camp to do the best possible with wholly inadequate facilities. Colonel Foote had said, "We propose to use whatever guns we can get, big or little," and the First Camp accordingly did its work on 3-inch field pieces and the regular seacoast armament of Fort Monroe, Not till months later were any heavy field guns available.

This ten-day firing practice, in the words of the report which describes it, was believed to be "the first actual firing on heavy guns in this country according to the system now generally in use in Europe, making use of airplanes and *kite balloons* for the observation of fire, and disregarding all methods whose application is restricted to the use of fortress artillery." Targets were located by a hectometric grid, the battery officers using a British firing board. Battery Eustis made a hit the first shot and all the heavy batteries placed their first shots very close to the target.

Quoting the official report further:

"The methods in use by the Allied heavy artillery in France today vary only in detail from the methods which have been used by the United States Coast Artillery for years. The underlying principles are identical, and the variations in the details of their application are astonishingly small. The fundamentals of heavy artillery gunnery remain the same whether the fire is directed over water or land. The problem for land batteries is somewhat more simple, in that seacoast batteries are compelled to use a system of fire direction which will allow them to attack targets moving at the utmost speed of modern naval ships. . . . The indirect method of fire is habitually practiced by Coast Artillery against moving targets, as in the use of seacoast mortars; a better preparation for "map switches" could hardly have been devised.

"In preparation for this firing, the Coast Artillery School was favored in receiving the advice and assistance of several officers of the French and British artillery, and Flying Corps, who added materially to the information which had been gained from the publications and translations furnished by the War College. Advantage was taken of this opportunity to test during actual firing some of the instruments recently devised by the Coast Artillery for the direction of fire of heavy guns in the field, such as the T-O-B clock, the deflection corrector, and the T-A-B clock (a modification of the British aerial observers' clock) which was tested in comparison with the French artillery system of signalling the deviations observed from aircraft. . . . A kite balloon was available for observation during part of the firing, and considerable practice was afforded in the observation of artillery fire from simulated "forward observing posts," with ranging upon an oblique line of observation. Some interesting experience was also obtained in the attempt of aircraft to locate a camouflaged battery while the latter was in action.

PREPARATION FOR THE FIRING

"Since there were available no heavy guns other than the seacoast armament, (except for a few 5-inch siege rifles and 7-inch howitzers, none of which were equipped for indirect laying), it was evident that the actual firing must take place from the seacoast armament. Steps were accordingly taken to utilize these guns and mortars in such a fashion as to accurately simulate field conditions. Artillery boards of the British pattern were improvised, upon which each battery commander located the position of his battery by plane table resection. A 'grid' of the available target area was prepared and all targets indicated and ranges obtained by the means in customary use among the Allies' artillery.

PRACTICES

"All firing during this period was held by indirect laying. In the case of those seacoast guns to which panoramic sights could not be attached, the pieces were laid in direction by means of the azimuth circle. Targets were assigned to the battery by means of the grid system, the exact location being designated by the co-ordinates of the selected point in the grid square assigned.

AEROPLANE OBSERVATION

"Airplanes were present during the firing of each heavy gun and mortar battery; one machine was used for spotting and the others observed. All communication to the ground was by radio, and was received by a field wireless set temporarily installed at the battery firing.

FIRING THE 12-INCH MORTARS

2208

"For communication of messages from the battery to the airplane, a system of 'ground signals' was used, according to the method described in the instructions issued by the French General Staff, G. H. Q. of the Armies of the North and East, dated January 19, 1917.

PRACTICE IN RANGING ON THE LINE OF OBSERVATION

"For Battery Irwin, (3-inch seacoast guns), forty rounds of ammunition were available, and for this reason this battery was selected for practice in registering, map-switches and the use of the T-O-B clock in ranging on the line of observation. Indirect fire was used here, as with all other batteries; panoramic sights taken from the field guns were attached to the seacoast carriages by improvised mountings.

ARTILLERY PRACTICE

"The method of emplacing the field guns was that most recently adopted in France for the concealment of their 75 mm. pieces. The guns were not dug in, but were merely concealed from overhead observation. The location assigned the battery was on a sandy beach, sparsely covered with bunches of grass. For the purpose of concealment, a frame was constructed over the guns, and across the top of this was stretched chicken-wire. This was covered with burlap, daubed with paint to the color of the sand, and to this were attached at suitable intervals bunches of excelsior painted the color of the adjacent grass tufts. Irregular holes were cut in the burlap, and a back curtain of similar construction was added. All slopes were made at angles not exceeding 30 degrees with the ground level. The muzzles of the guns were painted sand color, with large patches of blue and brown.

"During the firing of this battery, four airplanes from Langley Field, Virginia, informed of its approximate location, attempted to locate it definitely. Lieutenant LaMaitre, an experienced aviator of the French Army was one of the observers. During the half hour allotted to this part of the problem, the battery was fully manned, but refrained from firing during such periods as any of the aircraft were in a favorable position to observe. All the planes came over at about 7000 feet, and gradually descended to a position not far above the battery. They reported that they were unable to detect its position until after the expiration of the half hour assigned, after which time the precautions for concealment had been discontinued, men had walked around the battery, and firing had been carried on without regard to the position of aerial observers. The flashes of the guns could then be seen. On the following day, another flight over the battery was made by a French officer, but on this occasion the battery could not be seen at all.

Results of the Practice

"The most striking feature connected with the practice was the illustration of the ease of conversion of our coast artillery system of fire direction to the system universally adopted abroad. The system which has been perfected after three years of warfare in Europe is practically identical with that which had been in use in our coast artillery since 1904, with some slight modifications and refinements which relate principally to meteorological corrections and the utilization of aircraft for the observation and correction of fire.

"During the practice period, it was found feasible to fill any existing gaps in our mobile artillery equipment by the substitution of the corresponding seacoast instrument. Thus, due to a shortage of Elevation Slide Rules, C.A.B. Model of July 1, 1917, it was necessary to substitute for the heavy guns a Pratt Range Correction Board, Model of 1905. No confusion was caused by this, however, for the latest development for the use of the mobile artillery is identical in principle with the seacoast range correction device which has been in continual use during the past twelve years.

"In view of the fact that most of the candidates had but about six or seven weeks of artillery instruction, and no previous experience along such lines, the success of this firing is felt to be most encouraging. It is believed that the unusual level of intelligence of the candidates contributed in no small manner to the good results obtained. In view of the high character of the personnel, it is most regretable that no more suitable material was available for their instruction. To experienced officers, with a thorough understanding of what was intended, the simulation of and substitution for the actual means and methods which are to be used later was fairly convincing, but to a novice the demonstration must have been far less satisfactory. It is impossible to exaggerate the great value which would have been derived, had the camp been equipped with a single piece of modern heavy field artillery, or an actual railway mount for one of the heavy guns. It is earnestly to be hoped that inasmuch as practically all the candidates attending these camps are destined to serve with mobile heavy guns or howitzers in the field, that for the training of the second and subsequent classes there may be provided at least a specimen of the type of weapon with which they must necessarily be equipped."

This appeal for matériel of a sort which would make the instruction fit the task of the Coast Artillery was to be re-echoed in the time of the "second and subsequent classes." But the ordnance output of the United States was more than overstrained by the necessities of the fighting program, and matériel for instruction was slow in coming.

On August 15 the graduates of the camp, 766 out of a total of 1216 candidates, were commissioned. Two hundred of these were offered and accepted provisional commissions in the Regular Army (Cost Artillery Corps). The others were commissioned chiefly in the Coast Artillery Reserve Corps, both age and attainments being taken into consideration in the award of rank. The number of captains was 137, first lieutenants 103, second lieutenants 326.

Two hundred officers were sent overseas at once, about fifty were detailed as instructors and about twenty-five for company officers in the second camp; the rest were sent to the Coast Defenses.

Second Training Camp

As the military program of the United States began to develop, it soon became obvious that a second series of training camps for civilian candidates for reserve commissions would be needed. The revised Special Regulations No. 49, published on August 15, 1917, showed some important differences in plan between the first and second series, though in broad outline they were alike. The uniform "First Period" for candidates in all branches of the service was abandoned. Separate courses for Infantry, Cavalry, and Field Artillery were arranged, and while the Coast Artillery contingents were to take a four weeks course of instruction with the infantry, they were from the beginning of the camp organized into separate companies. The camp commander, assisted by the senior instructor, was to divide the student personnel between the arms of the service at the beginning of the course.

Accordingly the "First Company, Fort Monroe Training Camp" was established at Plattsburg, the Second Company also at Plattsburg, the Third at Fort Niagara, the Fourth at Fort Myer, the Fifth, Sixth, and Seventh at Fort Oglethorpe, the Eighth and Ninth at Fort Benjamin Harrison, the Tenth, Eleventh, and Twelfth at Fort Sheridan, and the Thirteenth at Fort Snelling. The First Company, Fort Winfield Scott Training Camp, was established at Leon Springs, the Second and Third Companies at the Presidio of San Francisco.

In dividing the candidates between the branches of the service, the proportions used were 0.667 for Infantry, 0.294 for Artillery, 0.029 for Cavalry. "The division of the Artillery between field and coast" according to Special Regulations No. 49, was "an arbitrary one based on present availability of facilties and equipment for training coast artillery candidates." The total assigned to Coast Artillery from all camps was 1400. "The Coast Artillery companies, equipped as Infantry, will be given their first four weeks of training (Infantry) at the camps to which they first report. Their further training will be for the Leon Springs and Presidio of San Francisco companies, at Fort Winfield Scott; for all other companies, at Fort Monroe, and under such instructions and regulations as may be prescribed by the Chief of Coast Artillery."

To each of the training companies destined to complete their work at Fort Monroe were sent a captain and two lieutenants (the latter graduates of the First Camp) from Fort Monroe. The infantry instruction and preliminary training of these candidates was thus in the hands of Coast Artillery officers.

The infantry instruction which the Coast Artillery candidates shared had been modified, since the First Camp, by a great increase in the amount of attention given to trench warfare. During the second and third weeks of the course there were nine hours instruction in the use of hand and rifle grenades and the training and employment of bombers. The fourth week was given over to the construction of fortifications and trench warfare, the entire command occupying the trenches for two days, under simulated battle conditions.

While the candidates of the Second Camp were receiving this training about fifty instructors recruited from the graduates of the First Camp were taking a rigorous normal course to prepare for the work of the two months at Fort Monroe. Obviously the Coast Artillery could not afford to detain as instructors a sufficient number of Regular officers to man the whole camp. It was therefore necessary to build up an instruction staff out of the new officers and to renew this at the end of each training camp so that the doubly trained officers of the "faculty" might be progressively released for overseas service. This theory was maintained throughout the successive camps, though as a matter of practice there were many officers whose efficiency as instructors and in administration of the School, led to their being retained during several camps or even up to the bitter end.

The call for real heavy artillery matériel to work with, which had been made in the report of the First Camp target practice, was repeated by the new commandant, Major E. J. Wallace, about a week before the Second Camp assembled. On September 14, 1917, he wrote the Adjutant General citing the program which had been officially laid down for the Coast Artillery in France, and continuing:

"The fact that necessity exists for manning oversea coast fortifications and the mine defenses of the United States with regular troops indicates that these defenses are to be maintained at their maximum state of efficiency and that the majority of officers assigned to such duty will be more experienced than those now in the Reserve Corps, and therefore the large majority of reserve officers trained here will be eventually assigned to duty with artillery in the field.

"In view of the above it is imperative that in addition to training in coast artillery methods and matériel, the best possible instruction in heavy field artillery matériel and methods of fire control be given at this camp."

He recommended, therefore, that two heavy guns, preferably French 155 mm. long, be secured, with ammunition for training 1400 men; that a French officer of artillery be secured as instructor; and that at least four Coast Artillery officers be sent to France for instruction, two to heavy and railway guns, two to anti-aircraft batteries. These recommendations bore fruit later—but not before several hundred more candidates had been trained with the inadequate facilities then at the disposal of the School.

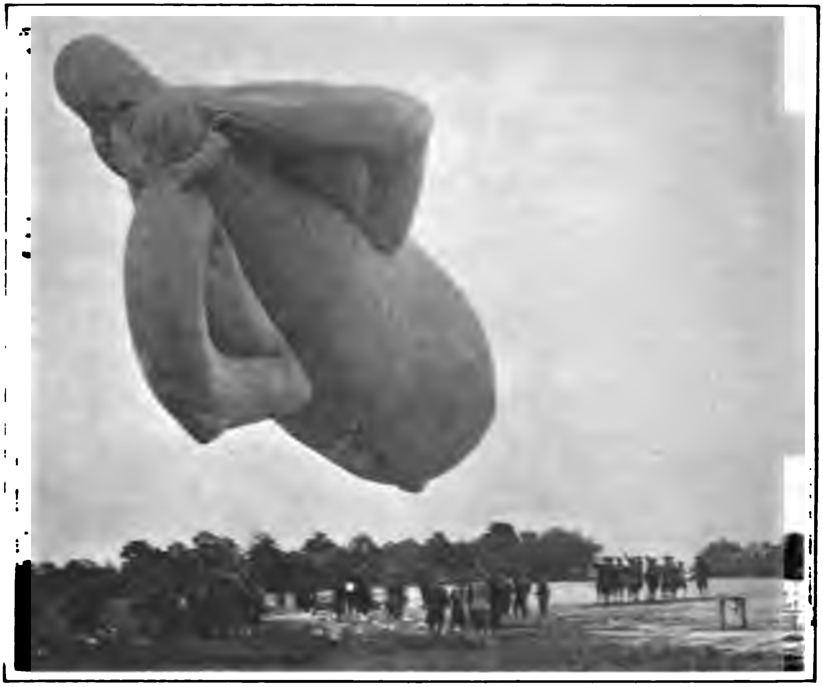
September 22 found 1277 candidates on hand to begin their two months' artillery course. The Coast Artillery officers who had commanded most of them at the general camps returned with them. In addition to the candidates from the divisional camps, there were 126 provisional second lieutenants who had been commissioned from civil life after examination, but who had not received the equivalent of a Fort Monroe training course, and about fifty enlisted men from the Regular Army.

While the instruction was amplified in several important respects the arrangement of courses and the general scope of the training was much like that of the First Camp. Particular development will be noted later as the history of each department is traced. The courses were as follows: Mortars (Service of the Emplacement, Matériel), Major Caliber Guns (Service of the Emplacement, Matériel), Map Reading and Field Fortification, Coast Artillery and Mobile Artillery Gunnery and Ammunition, Artillery Defense and Fire Control and Direction, Mechanical Maneuvers, Telephones and Signalling, Administration and Mobile Artillery. To the War Game instruction in the course called "Artillery Defense" had been added new material from British and French sources which had been published in the various pamphlets of *Field Artillery Notes*, with the T-A-B and T-O-B clocks. Administration had been expanded to a fairly inclusive course of 24 lessons on Army Regulations and Courts-Martial.

By the side of the highly organized curriculum of the latter camps these first courses seem rather numerous and not very well defined. The magnificent title "Coast Artillery and Mobile Artillery Gunnery and Ammunition" masked the course which has now become Gunnery, but it included also some matters, involving seacoast armament and ammunition generally, now handled under the head of Matériel. Map Reading and Field Fortification has grown into the present course on Orientation and Field Fortification. Administration has developed logically and without marked alteration. Telephones and Signalling fell by the wayside. Mechanical Maneuvers came under the wing of Matériel. The remaining courses, Artillery Defense and Fire Control and Direction, and Mobile Artillery, contained some matter that has been entirely abandoned, some that has gone over into the course in theoretical Gunnery, some Matériel and a trace or two of Orientation. The whole curriculum needed overhauling, but it testifies to the experimental nature of the work that was done at home while the Coast Artillery Corps was struggling with its new problem and the American armies were just beginning to get into France.

The work of the Coast Artillery Training Camp was sharply challenged on October 27, 1917, by General Pershing, who cabled:

> Fifty per cent of the officers of the Officers' Reserve Corps, Coast Artillery, who have been assigned to the heavy artillery are so lacking in elementary mathematical education as to give little promise that their services will be of practical value to the heavy artillery service in France. Request that in future officers who are without a working knowledge of geometry, *plane* trigonometry, surveying, and the use of logarithms be excluded from those sent to France for duty with the heavy artillery.—PERSHING.



OBSERVATION BALLOON [illegible]

Since it was manifestly impossible to teach the fundamental mathematics during the crowded three months of the training course, the deficiency to which General Pershing called attention had to be corrected by a more exacting selection of candidates—or not at all. The Commandant of the Training Camp remarked in a letter following the cablegram that before the opening of the second camp "every effort was made to procure the attendance of only such candidates as were thoroughly grounded in elementary mathematics. The candidates received from some of the training camps were carefully selected in this respect, but unfortunately this is not true of the candidates from all camps."

Once men without sufficient methematics were in the training camp, what was to be done with them? The Commandant suggested that since there were in the second camp men so handicapped who were "excellent material for officers in other branches of the service" and it was not thought "that the services of these men should be lost to the country," they should be admitted to the third series of general camps. The War Department did not approve this, but authorized the Coast Artillery Training Camp Board to recommend such men for commissions in the infantry, and accordingly at the end of the Second Camp two first lieutenants and 17 second lieutenants of Infantry were graduated from Fort Monroe. In later camps many men similarly situated were merely sent back to their coast defenses.

A Brisk Drill in the Mortar Pits. "Details Post" 2210

Altogether 818 new commissions were given at the end of the Second Camp, on November 26, 1917. Of these, 147 were as Captain, 338 as first lieutenant, and the rest as second lieutenant. A hundred men were sent overseas at once; the greater part of the class, as in the First Camp, went to the coast defenses, to train recruits and organize overseas units.

Target practice at the end of the Second Camp was in charge of the instructors in seacoast matériel, each company being assigned to a battery. The Gunnery Department furnished a corps of instructors to take data and make analyses. The firing, like that of the First Camp, was arranged to simulate what was known of Western Front methods. An adaptation of the British grid system was used, with airplane and balloon observation. All the batteries except DeRussy fired at fixed targets. Battery DeRussy was fired at a moving target and hit it. The target, a triangular white flag just visible on the horizon at a range of about 13,000 yards, was knocked out of the water on the fourth salvo. The Battery Commander called his method of Adjustment "Case IV" and let it go at that. The guns were already "in battery" for the next salvo before the absence of the target was verified, whereupon the smallest candidate in camp, stripped, crawled into the powder chamber, and removed the baseplugs so that the projectiles could be withdrawn. Various problems of a heavy field battery were illustrated at the three-inch seacoast battery.

At the end of the camp some of the instructors were formally attached to the Staff of the Coast Artillery School, but the whole teaching force was not given this status till the reorganization which preceded the Fourth Camp.

THE THIRD CAMP

Meanwhile the Coast Artillery Corps as a whole was being greatly enlarged. A memorandum from the Chief of Staff dated November 1, 1917, directed the formation of Training Units, Coast Artillery Corps, National Army, and stated that the Coast Artillery Corps, N. A. would be "progressively increased, to begin immediately, to approximately 70,721 officers and enlisted men in each army of the American Expeditionary Forces in Europe."

These recruits must be made to yield their quota of officer material, just as the cantonments were doing for other arms. Accordingly, in a letter from the Adjutant General of the Army, October 30, 1917, it was provided that a Board of Officers should sit at each Coast Defense to select qualified enlisted men for training at Fort Monroe. The Coast Artillery

Training Camps were standardized by the same instructions. Camps of three months each were to begin on the first Saturday of January, April, July, and October, 1918, ending on the last Wednesday of March, June, September, and December. Successful candidates were to be commissioned second lieutenants, no higher rank being given. Unsuccessful candidates were to be returned to duty with their organizations.

The Second Camp had ended on November 22. During the month of December about 250 provisional second lieutenants commissioned from civil life were on duty at Fort Monroe, receiving a month's infantry training before entering the artillery camp. They were joined on January 5 by about 350 candidates, enlisted men from the Coast Defenses, the total enrollment of the camp being 613. Of the 350 enlisted men, not more than 50 were professional soldiers. Among this group were many men of long service with the Coast Artillery, both non-commissioned staff officers and others. The other 300 were men who had enlisted after the the entry of the United States into the war, or had been drafted into Federal service with units of the Coast Artillery National Guard. Some of the provisional second lieutenants had been drifting from camp to camp while the training system was gradually working itself out. Some of the old service men were letter perfect on drill but not particularly adaptable. It was a harder lot of men to teach than the enthusiasts of the First and Second Camps.

The Third Camp was a small one, but nobody who experienced the temperatures which characterized the winter of 1917-18 wonders that even the muster roll contracted. The Bay froze over. At the batteries the command "remove—ice!" had to be injected into the proceedings before the guns could be tripped. The candidates quartered in the long barracks, who had to brave the outer air to reach the wash-houses, wasted no water. A certain section was scheduled to study a seacoast battery for thirteen days; on all but two the guns were effectively camouflaged by blizzards and storms.

While the camp uniform was the same at this time as before and after, some concession had to be made to the numerous provisional second lieutenants on the post. They were allowed to wear their insignia and uniform when leaving the barracks for the week-end; during working days they dressed and lived as enlisted men.

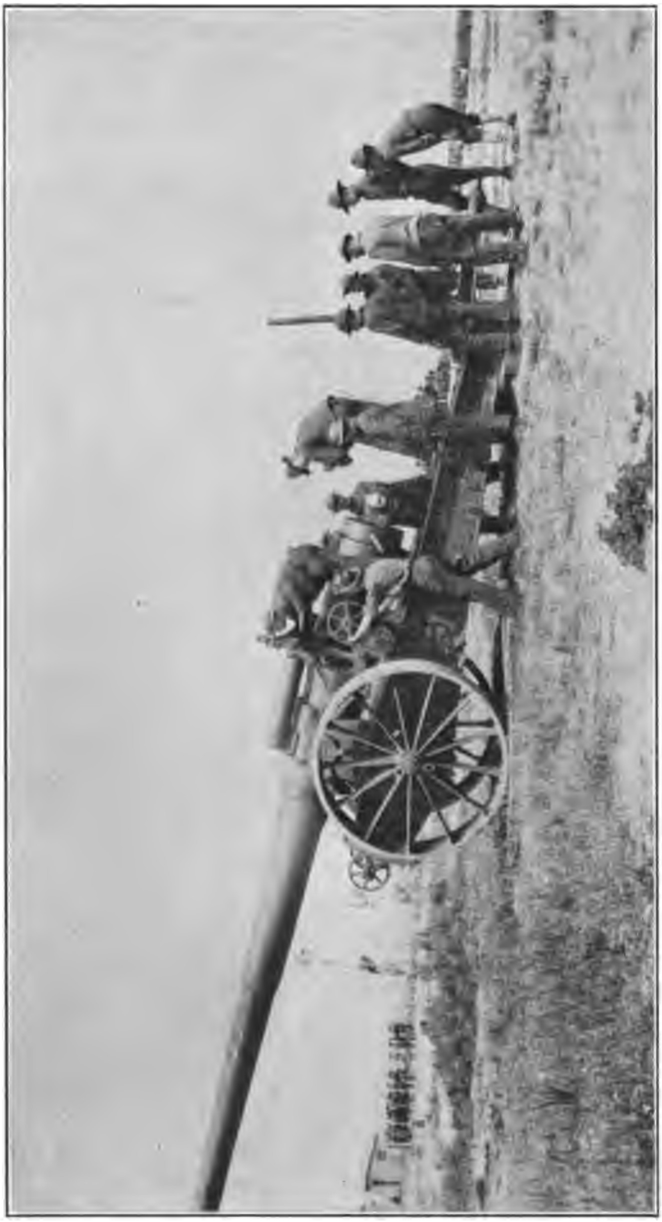
The curriculum showed some development from that of the Second Camp, but was fundamentally unchanged. The courses bore the same names and had the same general scope. Aside from the existing Army handbooks, the C.A.D.R., *Gunners' Instructions, Army Regulations,* and the like, no comprehensive text-books had been provided. A number of pamphlets, including *Field Artillery Notes,* translations from the French, hasty compilations from British, French, and American sources, were used in the courses which together covered the ground now divided between Gunnery and Matériel. The *Training Manual in Topography, Map Reading and Reconnaissance* was the backbone of the reading course in Topography, but there was no text covering the whole field of *Orientation for Heavy Artillery.* The student was not so completely dependent upon lecture notes as he had been in the First Camp, but he still lacked the help which the Mimeograph Department was later to furnish. Final examinations were given, without the frequent preliminary quizzes which have become characteristic of Fort Monroe methods. "Approved solutions" were unknown.

II

REORGANIZATION

In the middle of February General Sunderland (then Lieutenant-Colonel) and Colonel Welshimer (then Major), who had been on duty at the Heavy Artillery School of the American Expeditionary Forces at Mailly-le Camp, returned to Fort Monroe. With them came Captain Georges Charruey and Lieutenant Pierre Villemer, of the French Artillery. In March there also arrived the 8-inch howitzers and 6-inch wheel mount guns for which successive commandants had been praying. Thus the School gained almost at one stroke the American officers who had become familiar with French methods, the French officers, and the heavy mobile matériel, which, as Major Wallace had pointed out six months before, were essential to the successful conduct of a heavy artillery training camp at Fort Monroe.

Things began to happen immediately. The course in Topography was the first to feel the effect of the mass of information, in translation and out of it, in print and at the finger's end, which these four officers brought. Half the camp had finished its work in this subject, the other half was



6-INCH WHEELMOUNT

2211

just beginning. All classes were given a hastily improvised course of twelve one-hour periods into which was crowded as much of the French technique of orientation as could be mastered by the instructors over night and taught to candidates in the morning. Indeed the Topography department had the long end of the job of readjustment, for as the whole course was readjusted it became evident that their subject must logically be given at the beginning of the three months' curriculum, so that they had no interval in which to orient themselves before the Fourth Camp began.

It was different with Gunnery. It had been observed that under the rotary system under which the courses had been given, those sections which happened to study the guns and mortars before they took up theoretical ballistics made a much better showing in the latter work than those which reversed the process. That was natural enough; a man who has seen a gun and the things that make a gun work, and has familiarized himself with the special case of fire control represented by the plotting room and observing stations of the seacoast batteries, is much better fiitted to understand the trajectory and the ballistic coefficient, adjustment and dispersion, than one who is innocent of theory and practice alike. It was therefore decided to postpone all instruction in theoretical Gunnery until the latter half of the course, so that all candidates could first be taught Orientation and Matériel—both preliminary to the Battery Commander's problem. This gave the Gunnery department a considerable interval between the end of their work in the Third Camp and the beginning of the new course in the Fourth. *Gunnery for Heavy Artillery*, embracing material that had been published in *Notes on Ballistics*, *Reference Notes on Gunnery and Ammunition*, and in various bulletins of the Heavy Artillery School of the A.E.F., was compiled by Captain Meade Wildrick and published April 18, in time for the new course.

The logical reorganization of the curriculum put an end to the rotary system, and except for some minor variations due to the lack of matériel and equipment, all sections followed the same sequence of courses from this time on. The scattering courses of the First and Second Camps were grouped under a firmer administrative control by the organization of four distinct departments: Administration, Gunnery, Matériel and Topography (later Orientation). A mimeograph department was established to create a supplementary body of printed matter which could be cheaply and quickly produced and as quickly modified to keep step with changing information from the front. Numerous quizzes with "approved Solutions" were made a cardinal feature of the program. The whole work of the camp was thus reorganized, simplified in plan, and strengthened in content.

CANDIDATES USING TRANSIT ORIENTATION COURSE 2212

After the special lectures in Topography, the first notable effect of the new régime was seen in the target practice of the Third Camp. Lieutenant Villemer assisted in arranging the details. The Department of Topography furnished the battery commanders with the co-ordinates of the guns, the observing stations, the aiming-points, and the targets, and the meterological data for the day of firing. At the major caliber gun and mortar batteries the first of two days' firing was devoted to bilateral adjustment with balloon observation on the target direct. The second to adjustment on an auxiliary target, followed by aeroplane adjustment on the "unseen" target. A *planchette de tir* was prepared for each battery and the firing data, computed on Forms 7 and 10 of the American E. F. Heavy Artillery, was checked in this way. The point of impact chart, battery sheets, and bracketing came into their own. At the 3-inch battery a complete problem was solved, the practical probable error was determined, fire for adjustment was conducted with "esssai fire" and "amelioration fire" and followed by "fire for effect." The coefficient of adjustment, K_0, was computed at all the batteries and was used in subsequent firings. In one case unilateral observation was tried, with adjustment by bracketing along the O-T line.

At these guns the following problems were fired:

1. To find the probable error, muzzle velocity and bracket. Ten shots from No. 1 gun.
2. Adjustment of battery—bilateral observation. Adjustment by successive approximations.
3. Adjustment by bracketing—sense only of range deviation is known. One observing station only near battery.
4. Adjustment by bracketing—sense only of deviation is known. One observation station to the front and flank of the battery.

All companies also fired the mountain guns from the battery position back of Phoebus, using field methods. The practice was highly successful, as a demonstration of genuine Heavy Artillery methods, although it was curtailed by bad weather.

On March 26 the class was graduated. There were 202 new Second Lieutenants, and 245 provisional Second Lieutenants who had completed the course. No commissions in higher ranks were given. The total of 447 was much smaller than either of the preceding classes, and none of the new officers were assigned to immediate overseas duty.

THE FOURTH CAMP

The Fourth Camp began the new training course on April 6. Colonel F. K. Fergusson, who had arrived from France, assumed the duties of Commandant of the School, with Lieut.-Colonel Sunderland in immediate charge of the Training Camp and Officers School, and Major Welshimer as Director of Instruction. For the first time, a full schedule for the entire camp and a definite summary of the course were published in printed form for the use of candidates. The course as there outlined was as follows:

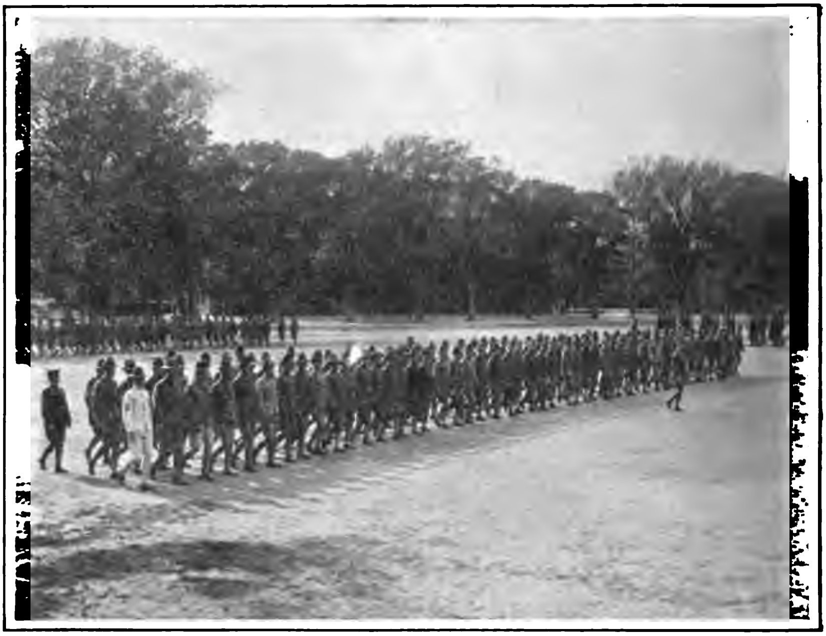
	Hours Gun.	 Mat'l.	 Topog.	 Admin.
Theoretical Gunnery	72	..	..	..
Seacoast Guns, Drill and Matériel	7	14	..	..
Seacoast Mortars, Drill and Matériel	7	14	..	..
Telephones and Field Buzzer	..	4	..	..
Mechanical Maneuvers	..	9	..	..
Heavy Artillery, Drill and Matériel	18	36	..	..
Topography and Map Reading	..	..	54	..
Field Fortification	..	..	27	..
Army Administration	..	..	..	52
	104	77	81	52

Twelve days, beginning June 24, will be devoted to applied gunnery and practical firing problems. Ten hours theoretical and practical instruction in Gas Defense will also be given, during the month of April.

MECHANICAL MANEUVERS ARE TAUGHT BY ACTUAL PRACTICE 2213

There were several novel features in this course. As has already been said, all the instruction at the seacoast batteries and the greater part of the work in Topography were given to all sections before they began Gunnery. The course in "Heavy Artillery" makes its first appearance. It had always been "Mobile Artillery" before, and had been based on the

3-inch field piece. The 8-inch howitzers and 6-inch guns which had been received too late for use in the Third Camp were now available to link up the instruction in Matériel with Western Front conditions. During most of the first four weeks of the camp, some section, every morning and afternoon, was taking an hour of Administration followed immediately by two hours of Gas Defense! Gas Defense at Fort Monroe was itself an innovation, dating only from March 1918.



PASSING IN REVIEW IN REGIMENTAL PARADE 2214

In Gunnery the fundamental change was the abandonment of the mechanical device theory of fire control and the substitution of plain straight-forward mathematical computation. To quote Captain Earl W. Thomson, the lecturer on Gunnery in the First Camp "always apologized for introducing sines and cosines accidentally, now and then, amid deep groans; no math was required of anyone, the supposition being that all the processes of the Heavy Artillery would be accomplished by mechanical apparatus or divine Providence." Among the mechanical devices much reliance was placed on a compound slide rule corresponding roughly to the Pratt Range Board, and familiarly known as the "coffin-box." Some mathematical flavor was introduced in the Second Camp, as an interesting innovation, through the initiative of instructors who went through the normal course after the First Camp. But the Battery Sheet was still a novelty at the end of the Third Camp, and it was the candidates of the Fourth Camp who first faced the daily dose of logarithms which made one casualty remark disgustedly, as he reappeared at his old station, that "They just wallow in 'em." Whether for this reason, or because of a fresh tightening of the ropes all around after the general overhauling of the camp, the Fourth Camp suffered a greater percentage of failures than any other. Only 63.6 per cent of the candidates received commissions, and there was no little concern over the lessened output, since officers were needed more and more.

COMING OUT OF THE GAS CHAMBER 2215

This was particularly disappointing because the War Department, staking the future of the School on the quality of the officer material included in the great dragnet of the draft and voluntary inductions, had issued instructions on February 20, 1918, that only enlisted men were to be admitted to the Fourth Camp. It was expected that this rule would be strictly maintained in all succeeding camps, and voluntary inductions, even, were to be suspended after a date early in April. But this policy failed to meet the strain put upon it by the still greater expansion of the Army which was determined upon in the summer of 1918, and the camps had to be thrown open later to civilians.

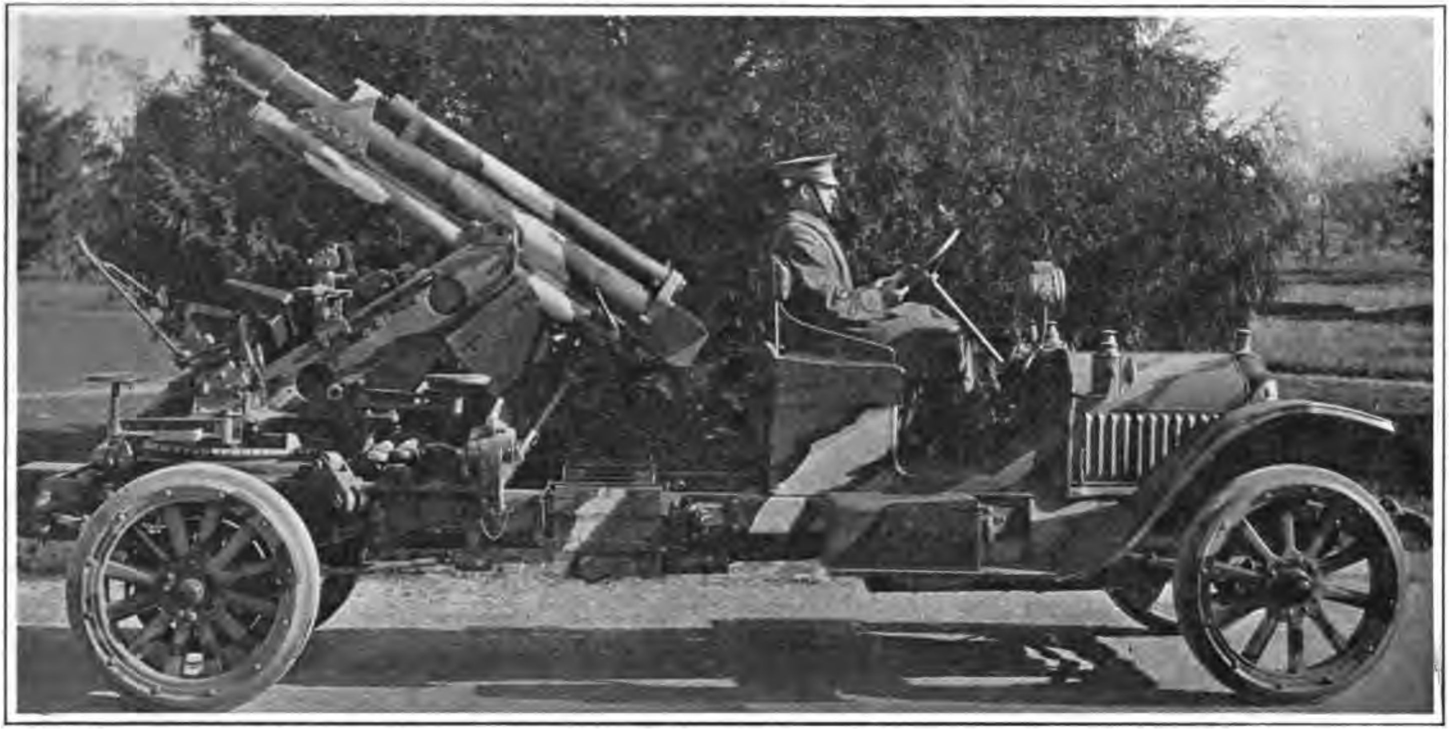
Little need be said of the target practice in this camp. In schedule it was like that of the Third Camp, but the weather prevented much effective work and most of the firing was done by correspondence after the conclusion of the Camp. When the guns could be fired, fixed targets located by a simulated Lambert grid were used. At Battery Church, practice with new range tables was inaugurated. This experiment was carried further after the Fifth Camp.

The total number of new commissions, 464, all of them as second lieutenants, was slightly larger than the output of the Third Camp, but much below the average. One hundred men received immediate overseas assignments.

THE FIFTH CAMP

Before the Fifth Camp a number of officers had been ordered to visit various calleges on a tour which was intended to stir up interest among desirable candidates. The trip was abandoned when they had barely gotten under way, but even their early efforts were enough to start a good many college men toward Fort Monroe, so that a large overflow company of men who could not be accommodated in the camp was formed when the Fifth Camp opened. With such excellent men for replacement, candidates who showed up poorly in the early weeks of the course were given short shrift, their places being taken by men from the "Reservoir" on the beach.

In the Fourth Camp a few squads of men who had received no drill with the rifle were armed with the new Enfield and given the manual and drill under arms. None of the candidates in previous camps had been armed with the rifle, but with the Fifth Camp the lot of the candidates was made considerably less lovely by the issue of Enfields to all the training companies. Friday night, which had been hitherto a time of release and rejoicing, was cankered by the necessity of preparing these curiously fabricated weapons for Saturday inspection.



A CAMOUFLAGED ANTI-AIRCRAFT "75" MOUNTED ON A MOTOR TRUCK.

As a slight compensation for this additional burden, the censorship on academic grades, which had been enforced in previous camps to a nerve-racking degree, so that a man never knew how near he was to the fatal edge, was lifted in the Fifth Camp. Frequent announcements were made of the standing of the candidates both in preliminary quizzes and in final examinations, and only the "company mark" kept its veil of awful mystery.

A more important change in instruction was the publication of the new textbook of *Orientation for Heavy Artillery*. This gave a new name and a more substantial body to the course which, as Topography, had been put together for the Fourth Camp to include the old map reading and all the new French Orientation.

Otherwise the course was much like that of the Fourth Camp. The shrinking remains of Telephones and Field Buzzer were finally eliminated altogether from Matériel, being represented only by a mimeographed bulletin of generous proportions which was distributed to all candidates and widely unread. Some adjustment of hours was made, and target practice was reduced from twelve to seven days.

This was the schedule:

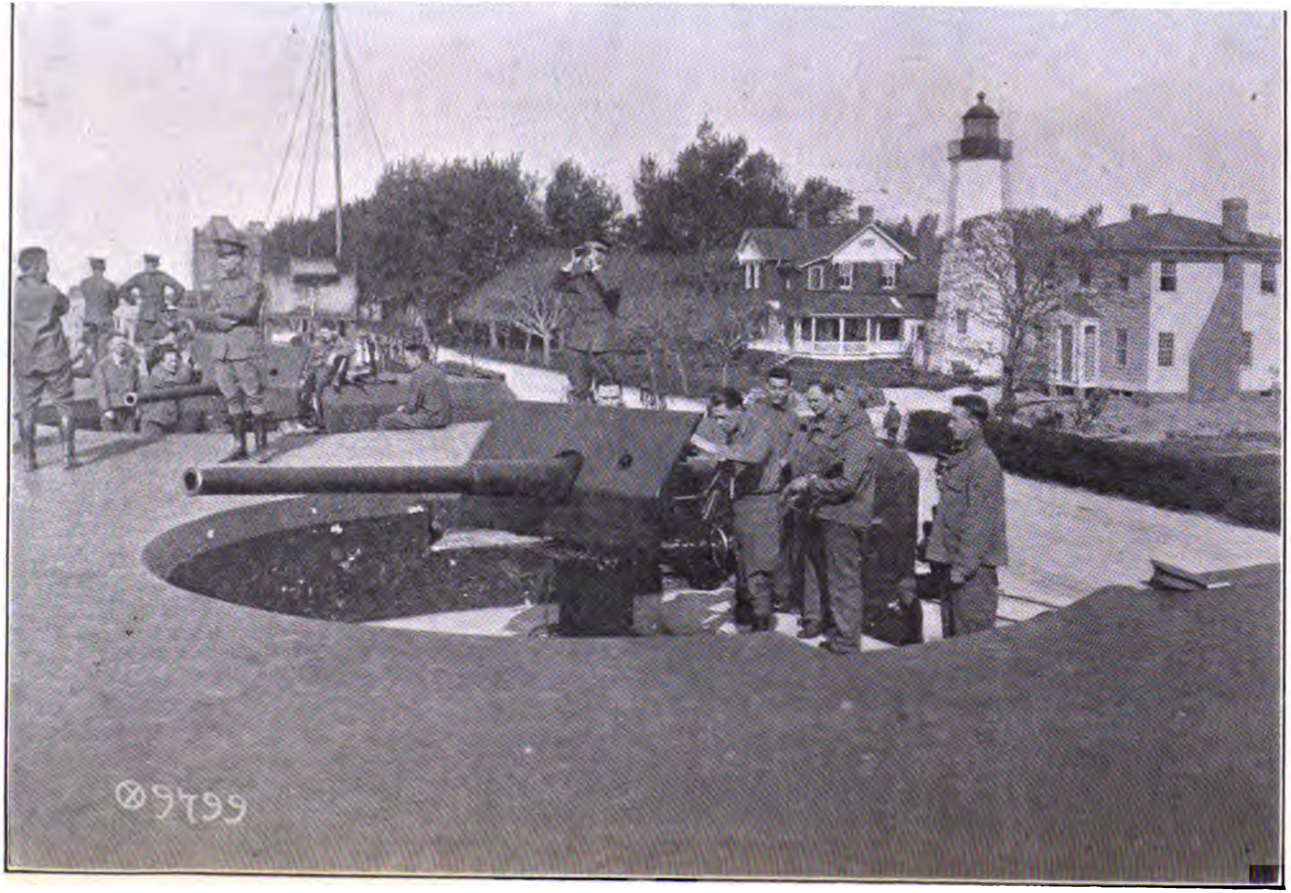
	Hours			
	Gun.	Mat'l.	Orient.	Admin.
Theoretical Gunnery	68	..	..	..
Seacoast Guns	8	16	..	..
Seacoast Mortars	8	16	..	..
Mechanical Maneuvers	..	9	..	..
Heavy Artillery, Drill and Matériel. Telephone and Buzzer	16	32	..	..
Orientation and Map Reading	..	..	57	..
Field Fortification	..	..	27	..
Army Administration	..	..	..	46
	100	73	84	46

The camp opened on July 6, with 981 candidates officially in residence, besides the men housed on the beach. By this time the old Coast Artillery Corps enlisted men had been pretty thoroughly combed for officer candidates, and while theoretically all candidates of the Fifth Camp were enlisted men from the defenses, there were only a handful who had seen any service (except in the National Guard) before the war, and there were many who had been inducted for the training course and had seen no service of any kind till a few days or weeks before the camp began.

If the Third Camp had been remarkable for its cold weather, no one who was in Fort Monroe during the month of August will forget a certain week which had its climax in two sweltering days which almost broke up the camp. The wooden section-halls to which most of the candidates were assigned for lecture and study-periods were almost unendurable. It was officially ruled, as a special concession, that black ties could be removed and O. D. blouses opened at the neck, though an instructor in charge of a melting section one night did specify that *both* O. D. shirts and cotton coats, buttoned up, must be worn. The saturation rose well above the level of the range table assumptions. Most of the instruction and nearly all the study during the hottest weather was done outside the section rooms, on the sides of the parapet, under any scrap of shade that could be discovered around the study-halls, and anywhere else that the instructor permitted. The time of the evening study period was advanced so that the men could take full advantage of the light for studying outdoors.

TURNING OUT 200 OFFICERS A WEEK. 2217

Firing practice at the end of the Fifth Camp, though covering a shorter period than in previous schedules, was



TARGET PRACTICE. RAPID FIRE BATTERY

2218

distinctly successful. It was run as a part of the course in Gunnery, which had been docked three days to permit proper preparation for the firing. The noval feature was the firing of the "six-inch terror" using the Mark III fuse. The purpose was to determine, if possible, the cause of the great dispersion which had been observed in firing at Mulberry Island. This has been found to be due to the lip on the rotating band of the projectile. A premature burst which slightly scratched a visiting instructor and two K.P's enlivened the proceedings. The 12-inch mortars were successfully fired with new range tables incorporating for the first time all the corrections ordinarily applied only to the guns.

At all the cost defense batteries new range tables computed by the Gunnery Department, on the new U. S. Field Range Table Form with metric units, were used very satisfactorily. Bug Light and Back River Light were used as observation posts. Communication with the former was by wig-wag, with the latter by radio phone. The battery commanders were gunnery instructors, and an orienteur and an emplacement officer were supplied for each battery from the appropriate departments.

One company, firing the mountain guns from the usual position, conducted all the normal orientation operations with distinguished success and fired a number of field problems, using nearly 200 rounds. In one problem aerial observation was provided by observers from Langley Field. A smoke-bomb problem, duplicating the puff-board in the field, was attempted, for the first time at Fort Monroe. But after the company had weathered half an hour of a heavy downpour it had to be abandoned.

The Army Unification Order (G. O. 73, W. D., August 7, 1918) announced that, "This country has but one army—the United States Army. It includes all the land forces in the service of the United States. Those forces, however raised, lose their identity in that of the United States Army," and provided that all distinctive appellations, such as N. A., N. G., R. C., etc., should be dropped and that all commissions "hitherto and in future granted" during the emergency were commissions in the United States Army. Provisional and temporary appointments in the Regular Army to the rank of second lieutenant were discontinued, though of course the permanency of commissions in the Regular Army was not effected.

"STANDING BY" 2219

RAMMING DETAIL IN ACTION 2290

Consequently, the graduates of the Fifth Camp on September 25, were all commissioned second lieutenants, Coast Artillery, United States Army. The number of these commissions were 696, the percentage of graduates to total candidates (70.9) well above that of the Fourth Camp. One hundred new officers were sent overseas at once. The plans already on foot for the great expansion of the training camp and the introduction of the continuous camp made it necessary to hold an unusually large number of men at Fort Monroe, and about 275 were detailed as instructors, company officers, etc. This left few officers to re-enforce the coast defenses, which were rapidly being depleted by the organization of overseas units. The need of new officers was very pressing.

A SECTION MARCHING TO RECITATION 2221

III.

THE CONTINUOUS CAMP

The organization of the Coast Artillery Training Center and the inauguration of the Continuous Camp really preceded the end of the Fifth Camp, but since they begin the new order, while the Fifth Camp was wound up according to older precedents, it is convenient to treat them separately. The Coast Artillery Training Center was created by Section II, G.O., 69, W. D., July 30, 1918, to include the Coast Artillery School, the Coast Defenses of Chesapeake Bay, and Camp Eustis. By September 19, 1918, its organization had been carried to a point where it was possible to announce its main outline in G. O. 5, Coast Artillery Training Center, which reads, in part:

> The Commanding General of the Coast Artillery Training Center commands, in a general way, all personnel and matériel within the limits of the Coast Artillery Training Center except such as may be excepted by higher authority. He is the intermediate commander between the Commanding Officer, Coast Defenses of Chesapeake Bay; Camp Eustis, Va.; Commandant, Coast Artillery School, and higher authority. The Commanding Officer, Camp Eustis, Va., commands all personnel and matériel assigned to Camp Eustis except such as pertains to these headquarters and to the Coast Artillery School. The Commanding Officer, Coast Defenses of Chesapeake Bay, commands all personnel and matériel within the territorial limits of the Coast Defenses of Chesapeake Bay except such as is assigned to these headquarters and to the Coast Artillery School. The Commandant, Coast Artillery School, commands all personnel and matériel assigned and pertaining to the Coast Artillery School and its various branches.

By the further provisions of G. O. 13, Coast Artillery Training Center, November 6, 1918, the Coast Artillery School was reorganized with an Officers' Department, which included both the Candidates' School and the Officers' School; an Enlisted Men's Department, which included all the courses for Enlisted Specialists existing before the war and the Motor Transportation Course; and a Tactical Department. The candidates' course was thus rammed home into the organization of the Coast Artillery School, after a long period of uncertain adjustment. It was first allotted to the Commanding Officer of the Coast Defenses of Chesapeake Bay, and was entirely distinct from the Coast Artillery School. The School itself had continued its regular courses for officers in the class of 1917, until about June 1 of that year entirely apart from the Train-Camp, and gave a series of six or eight weeks' courses for officers, between January 5 and September 6, 1918, which were designed to supply the lack of overseas technique in the training of officers who had not taken the Candidates' Course. In the Fourth Camp the Training Camp had been brought under the administrative control of the Coast Artillery School, but was not fully integrated with it.

Meanwhile the Candidates' School was being radically made over to meet the new need for officers and still more officers. The Coast Artillery Training Camp like the other camps had begun work with the officers of "the first 500,000,"

2222

Department of Enlisted Specialists, C.A.S.

New Construction

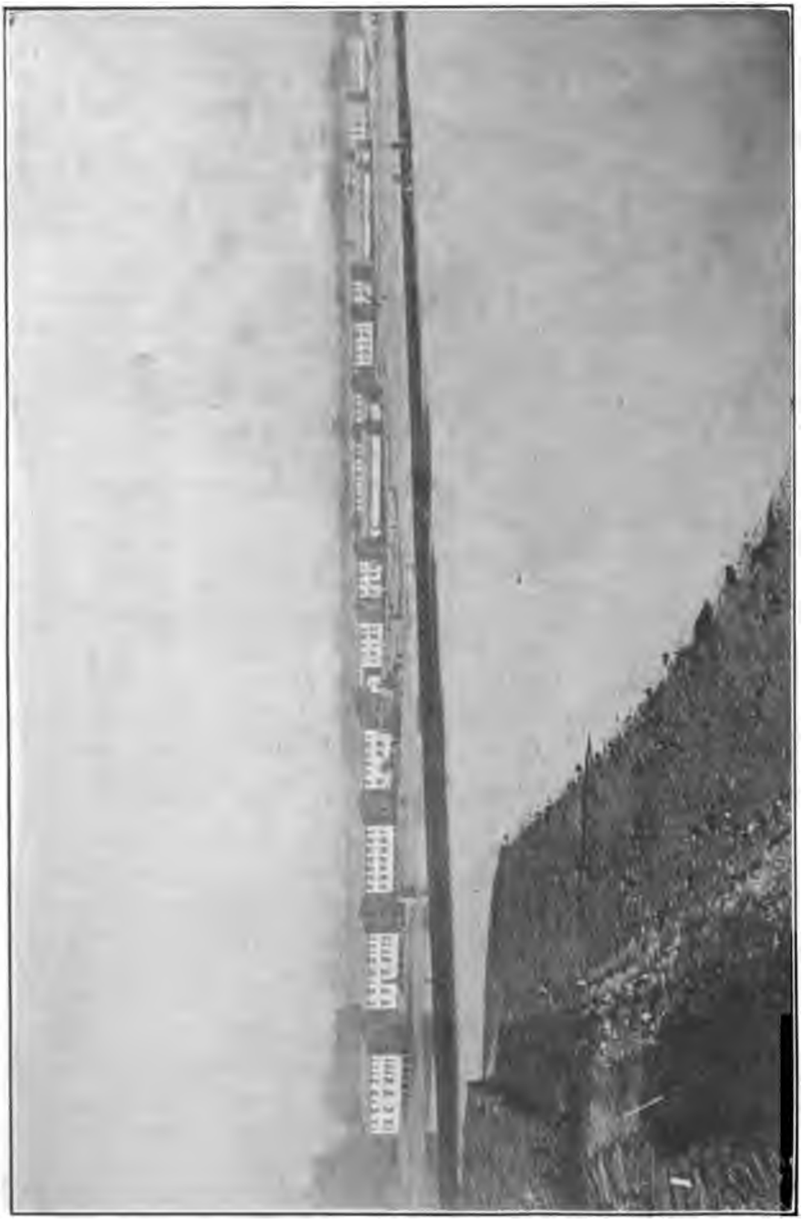
and as increment after increment was authorized it had barely kept pace with the demand for commissioned personnel. But when the American Army began to be defined in terms of three or four millions, the scheme of successive three-months' courses became obviously inadequate. Something bigger, something which revolved more rapidly and produced a constant output, was necessary.

Under the old plan, only candidates with three months prior service in the ranks were to be admitted into what was to be the Sixth Camp, scheduled to begin on October 5. By August 16 this restriction had to be abandoned; the Chief of Coast Artillery wrote to the Commanding General of the Coast Artillery Training Center, in part, as follows:

> 1. A greatly enlarged program laid out for the Coast Artillery calls for an increased number of officers. All reasonably qualified candidates will therefore be sent to the next course, regardless of length of service. This course will begin October 5 and end December 21, 1918. ...... You will quarter then in any available barracks, and use tentage if necessary.

But this concession did not meet the necessity and at Fort Monroe a new plan providing for a continuous camp, with a company of 200 candidates beginning work every week, was devised. By the first of September it had been approved in principle by the Chief of Coast Artillery, and on the 3rd General Sunderland wired that the Training Center was "prepared to start first class of 200 artillery candidates September 14 and to continue 200 every week from then on provided building program can furnish class room buildings one per week beginning October 12 and barrack units one per week beginning October 19." On September 8, Colonel Welshimer was appointed Commandant and General Sunderland detailed as Senior Instructor, Coast Artillery Training Center.

More will be said of this building program later. On the next day Washington replied that full classes could be furnished for the Continuous Camp for several weeks to come, and that it was desirable to begin on September 14. On September 13, accordingly, the 17th Company of Chesapeake Bay, 200 strong, which had been organized in July as an overflow from the Fifth Camp, and had been drilled and coached till it was more than ready for the training camp, changed its red hat cords for red, white, and blue, and marched to the section rooms to take its place as Company A of the Continuous Camp. Company B, with 217 members, began its work September 23; Company



Department of Enlisted Specialists, C.A.C.

TWENTY-FIVE ACRES ADDED TO THE RESERVATION BY THE MILL CREEK FILL

2223

C, 208, September 30; Company D, 211 October 4; and the Continuous Camp was well under way.

It had from the first been one of the most difficult problems of the Training Camp to get properly qualified candidates. The requirement of mathematics had been recognized as essential, but not standardized. The coast defenses, in some cases, failed to select their men as carefully as was desirable. On July 27 the Commanding Officer of the Training Camp commented in a letter to higher authority on the disappointing quality of the men picked by the coast defenses, and continued:

> Men with no military bearing and little aptitude should not be sent forward as candidates for officers. About 20% of the failures in every training camp are due to a lack of military qualities...... It does not appear possible to properly select candidates for this Camp unless they are given a short written examination, which should prove ability to handle elementary mathematical problems. It is strongly recommended that the Training Camp be authorized to make up an examination which will be uniform throughout the Coast Artillery service, and send it out to the coast defenses, with suggestions as to the selection of men and the method of grading men on the examination thus sent out.

He also recommended a national publicity program for the month of August which should acquaint desirable men still in civil life with the opportunities offered and qualifications required by the "Big Gun Corps," as it was rechristened for the occasion. This campaign was placed in the hands of a Communication Officer and became very successful in stimulating applications for admission to the Camp.

The Preliminary Examination in Mathematics

Some of the Defenses had already adopted informally a preliminary examination of candidates for the School as an aid to the decision of the Board of Officers to whom the selection was officially entrusted. The examination was now made compulsory in all Defenses, and the general problem of standardizing methods of admission to the Camp was turned over for study to the newly appointed Inspector of Instruction.

This problem was soon to be complicated by the extension of the draft ages both downward and upward, and the resulting creation of the Student Army Training Corps as a link between the colleges and the Army. Qualified students could be withdrawn from the S. A. T. C., before the completion of their training if they could be fitted into the Training Camp scheme without clogging the wheels. Men of this class began to arrive at Fort Monroe in the second week of October, and altogether more than 1000 were received from college units all over the country. On the other hand there were now many older men whose experience in business and the professions made them especially good officer material, but who had been out of school so long that they were in need of coaching in little used mathematics.

Since small detachments from the S.A.T.C. and from the Defenses and individual candidates inducted from civil life, under the new and liberal rulings on this point, might be expected to arrive almost continouusly, the Reservoir Company which had been established to care for overflows from the Fifth Camp was made permanent as a sort of Depot Brigade for the Candidates' School. There the new arrivals were received, partly equipped and drilled, and there as the plan developed, they were all (except the candidates already examined at the coast defenses) given a qualifying examination in geometry, algebra, trigonometry, and logarithms.

If a man could pass this examination, he was

CANDIDATES AT PARADE

2224

ready for the training camp, and he was enrolled in the next company to be formed. Since a company entered the Candidates' School every week, no great delay ordinarily occurred. But if he could not pass, he was placed in a mathematics class where he was coached on the particular parts of mathematics in which he was deficient for a week, or two, or three, or even six weeks, until he could repeat the examination and qualify.

By dividing the students of mathematics into groups according to their individual needs they were made ready for camp with a minimum of delay. The distinctive feature of the course was its liberal use of field work as a point of departure for theoretical instruction. Simple problems in surveying and map study formed the basis for typical computations, and while the student was picking up the elements of trigonometry he was also learning how to handle a transit and stadia rod and to read a map.

Thus the Reservoir Company became the regular road of entrance to the Candidates' School, and a standardized examination in mathematics the gate through which all candidates passed. Both the youngster from college and the man of thirty or forty could be accommodated in this system and class work in the camp itself was considerably facilitated.

CHANGES IN THE COURSE

In the Candidates' Course itself there were changes which strengthened it without any violent alteration. Now that the companies entered the camp in rotation, it was possible to get rid of the last traces of the rotary curriculum which still remained in Matériel and Orientation, where there had not been enough guns or transits to accomodate seven or eight hundred students all studying the same thing at the same time. Matériel was gathered up into one consecutive course at the beginning of the camp, so that a student went from one gun to another and cleaned up the minor courses in mechanical maneuvers and ammunition and disposed of the whole subject before beginning Gunnery and Administration, which divided the entire time during the latter part of the course. The theoretical part of the course in Aiming and Laying which had been given by the Matériel Department was now transferred to Gunnery, where it logically belonged, while the Matériel department continued to explain the sight and aiming rules, etc. New Guns, 7- and 8-inch railway mounts, were added to the equipment and given a place in the Matériel course.

In Orientation, a revised edition of the text-book was issued, and all the French terms which had been carefully learned by instructors and students in the earlier camps were laborously unlearned in favor of more or less Anglo-Saxon names like "Y-azimuth" and "drying shot."In Gunnery, also, a revised text, considerably altered and with new range tables, was published. Administration was reorganized to bring about a clearer relation between the theory and the practice of company administration and a more thorough acquaintance with practical paper-work.

PRACTICAL GAS DEFENSE INSTRUCTION 2225

All these things one would observe if he attended classes and studied bulletins. But one could lie asleep in his quarters and still have forcibly brought to his attention certain other changes. A vigorous campaign for esprit de corps led, among other sprightly manifestations, to loud and cheerful singing by the candidates as they marched from their barracks to morning calisthenics about six o'clock in the morning, and at other times during the day and night. On Wednesday evenings, moreover, the parade ground was enlivened by vaudeville and musical entertainments staged by the candidates and sometimes by visiting artists. Altogether the gayety of nations was vastly more in evidence than during the sultry plodding history of the Fifth Camp, for instance.

Week by week the candidates' companies pushed their way nearer and nearer to Phoebus down the long Mill Creek Fill, until men were sleeping in half-finished barracks and studying in windowless shacks set in the midst of a sandy waste that made smart maneuvering by the sections fairly difficult. Companies E, F, G, H, I, K, L, and M followed each other without interruption, except some delay between E and F due to the epidemic of Spanish Influenza. A section of aerial observers, men who had already completed the course at an aviation ground school before coming to Fort Monroe to learn the artillery end of the observer's problem, was attached to each company. The capacity of the camp had been set at 3410 in the officers' department (including advanced students as well as candidates and the Reservoir). The Camp was rapidly approaching capacity. On November 11 there were 2780 candidates at Fort Monroe, of whom 2174 were artillery candidates in the Officers' Department, 397 were aerial observers, and 299 were in the Reservoir. Seventy men arrived and were sent home on the 11th.

A SECTION IN ORIENTATION 2236

On that day the Hun threw up his hands. The War ended.

AFTER THE ARMISTICE

The elaborate machine at Fort Monroe had been speeded up to a point where it could not be stopped in a moment. The Reservoir received new detachments and the enrollment went on climbing until 2933 candidates, observers, and Reservoir students were recorded. Nobody knew quite what was going to happen, but work went on.

AN EMBRYO ORIENTEUR 2227

Washington acted promptly. On November 14 a telegram from the office of the Chief of Coast Artillery announced the terms on which the Battle of Fort Monroe was to come to an end:

> Following instructions received: "The Secretary of War directs that no more candidates be admitted to officers' training schools. Candidates now in attendance will be allowed to complete the course, or will be discharged immediately from the Army or at any time prior to the completion of the course of instruction which they are taking, at their option. Candidates who were transferred from the Student Army Training Corps will be allowed the further option of transfer back to that organization, provided they return to college immediately. Those candidates who elect to remain at the school and who successfully complete the course of instruction will be commissioned in the Officers' Reserve Corps, under the provision of Section 27, Act of June 3, 1916. Candidates who are beyond the maximum age limit for appointment in the grade of second lieutenant may be commissioned in

the higher grades provided for in sub-paragraph 4, section 37, Act of June 3, provided they are qualified for such appointment, but no candidate will be commissioned in a grade higher than the lowest grade for which his age makes him eligible. If a candidate is beyond the maximum age limit for the highest grade for which he is found qualified he will not be commissioned but will be issued a certificate of graduation. Harris."

Appointments and promotions in "C.A., U.S.A" were suspended and the status of officers other than Regular Army offiicers in that classification was left to be adjusted by later regulations.

The opportunity to resign was given the candidates, and long queues of men waiting for signature to release papers, and this, that, and the other blanks, began to form almost at once.

8-INCH HOWITZER 2228

In two weeks after the signing of the armistice the enrollment of all candidates had fallen to 1893; within a month it had passed the thousand mark on its way down, three companies having then completed their courses and passed out. In the advanced companies, soon to complete their work, the percentage of withdrawals was naturally much smaller than in the companies which had nearly the whole course between them and release. But it is noteworthy that Company N with 183 members was organized several days after the signing. Taking the camp as a whole, rather better than one man in three decided to stay.

On November 23, 157 candidates were commissioned from Company A, followed by 158 from Company B on November 30, and 121 from Company C on December 7. To expedite the production of the needed officers, their course had been shortened to ten weeks by omitting target practice and one week of instruction. Under new regulations, these men were permitted to wear their officers' uniforms without shoulder insignia, during the last week of their course. This was, indeed, the only chance they had to wear them at all, while on military duty, since upon being commissioned they were placed at once on inactive service.

The remaining classes of the Continuous Camp were graduated at weekly intervals, each class marching in full panoply to receive its commissions and then promptly marching out into civilian life. The following companies were graduated:

Company	D	87
"	E	104
"	F	65
"	G	82
"	H	79
"	I	59
"	K	63
"	L	60
"	M	48
"	N	155

Companies M and N, which left Fort Monroe on February 7, 1919, were the last of the long line of new officers added to the military establishment by the Coast Artillery training camps. The roster of graduates had reached a total of 4432.

A study of the age and occupation of the candidates for whom records are available shows that while the war continued a majority of the graduates of the training camps were under 25 years of age, with the average rising slightly as it became more and more evident that older men would be needed; and that their occupations run all the way from the engineering professions, which (counting students, surveyors, etc.) ran as high as 30 per cent in some classes, through a long list of miscellaneous jobs all the way to "casket liner and orange picker."

IV

THE DEPARTMENT OF INSTRUCTION

While the high spots of the development of instruction in each of the major departments have already been touched on, it will be worth while to outline more particularly the way in which the very experimental teaching of the First Camp was worked over into the well organized curriculum which was in force when the camp came to an end.

ADMINISTRATION

The course in Administration sprang from a humble origin, and came into its own late in the history of the camp. In the First Camp, as had been said, it was confined to three or four lectures miscellaneously assorted, running from shoe-fitting to general courts-martial. But the candidates of this camp had theoretically been instructed in much of the matter now covered in the Administration course while they were at the general camps for the First period. There they had studied *Tables of Organization*, the *Manual of Interior Guard Duty*, *Field Service Regulations*, and a considerable part of *Army Regulations*. But the instruction which could be given at these general camps was not such as to guarantee a very thorough grasp of paper-work.

In the Second Camp Administration appears as an hour-a-day course with 24 reading lessons, 14 on Army Regulations and 10 on Courts-Martial. In the Third Camp this had been increased to 52 lessons—an hour a day throughout the camp. The first 34 were on *Army Regulations*, the rest on Courts-Martial. This was more ambitious, but the course was taught in a rather casual fashion, without quizzes or final examination, and little was to be learned by watching an instructor wave a blank before the class and dismiss it with a few words of explanation. Throughout the camps the instructors in Administration have been handicapped by inability to secure enough specimen forms to insure that every student knew them at close range and could use them intelligently. The expansion of the Army must be held responsible for the shortage of blanks, as for many other things. But before the Fourth Camp there were not even any specimens to put in the hands of a few candidates.

The overhauling of the curriculum which marked the interval between the Third and Fourth Camps had its effect on Administration. The new arrangement which put Orientation and Matériel at the beginning of camp, and Gunnery at the end, automatically pushed Administration to the latter half of the course, where it was given 52 hours in one and one-half hour periods. It was realized that an experienced company officer should be in charge of the instruction. An officer of nine years' experience was accordingly called in from duty in the field to head the department. Under his direction a new course was planned, including a brief survey of *Field Service Regulations*; mimeographs were issued in great number to supplement and clarify *Army Regulations* and to eke out the scanty supply of specimen forms; and the *Engineer Training Manual Appendix* No. 2 was secured as a secondary text-book to show how the forms looked when properly filled out. Frequent quizzes were introduced, and the course was considerably strengthened. A mock court-martial was introduced as the finale of the Court-Martial Course to give color to the instruction in this unexciting subject. Since lawyers were, by training, skilled in the handling of prescribed forms and the interpretation of statutory regulations, an effort was made to secure new officers who had been lawyers in civil life as the core of the instruction staff.

As it became necessary to train adjutants for the overseas units which were being formed with increasing rapidity, it was decided to pick instructors for the Administration Department who were qualified for the duties of a battalion adjutant, with the expectation that after mastering the details of army administration through teaching the subject in one or two camps, they would be ready for such duty without further delay. The early end of the war kept this plan from being carried into effect. A few graduates of the instruction staff were sent into administrative positions.

The course in the Fifth Camp followed the lines laid down for the Fourth, with supplementary bulletins and changes following each other at frequent intervals. The time was reduced to 46 hours. The department began to issue in mimeograph form information of interest and value to company officers generally, which was circulated throughout the defenses.

In the Continuous Camp the course was reorganized in the direction of a more logical development of the subject and closer integration between the reading lessons and the paperwork. The mimeographed bulletins were rearranged so the old designations of "First paper, fourth part" and the like, which made one instructor declare he always felt as if he were giving out a reading from the Psalms when he announced a reference, were replaced by a simple consecutive paging. While the supply of forms was still insufficient, the School did secure a much larger number of expendable forms than had been available before, and problems were therefore prepared which the candidates worked by filling out the more important forms for themselves. This was practical instruction of real value. It was made possible by the increase of the daily period from one and one-half to two hours, giving a total of 60 hours for the course.

Gunnery

This sketch of the history of the Gunnery Department is based on a lively account prepared by Captain Earl W. Thomson, C. A., assistant senior instructor when the armistice was signed, which is freely quoted and paraphrased.

The senior department of the Coast Artillery training camps began its work in the First Camp with four instructors, who taught chiefly exterior ballistics, fire control, and an inkling of what was to develop in the way of heavy artillery practice, but little real information as to what was going on in France. "No books were used, but frequent reading lessons in C.A.D.R., *Gunners' Instructions for Gun and Mine Companies*, *Notes on Ballistics*, and *Gunnery Notes* made it necessary to have a reading knowledge of the English language. It might be pertinent to remark that there were only about three of each of these books for each section and therefore studying at times devolved into a contest in which the best fighter was the best student; we were that eager to learn the art and science of operating guns. The instructors admitted that it was rather a hard job at times to relate their knowledge of Coast Artillery to the training of the candidates; it was skating on thin ice to talk about higher mathematics with three or four math Ph. D's. in the class; it was harder to talk of explosives when several explosive manufacturers were ready to pick all sorts of flaws in the discussion. Such was the diversified training of the candidates of the First Camp."

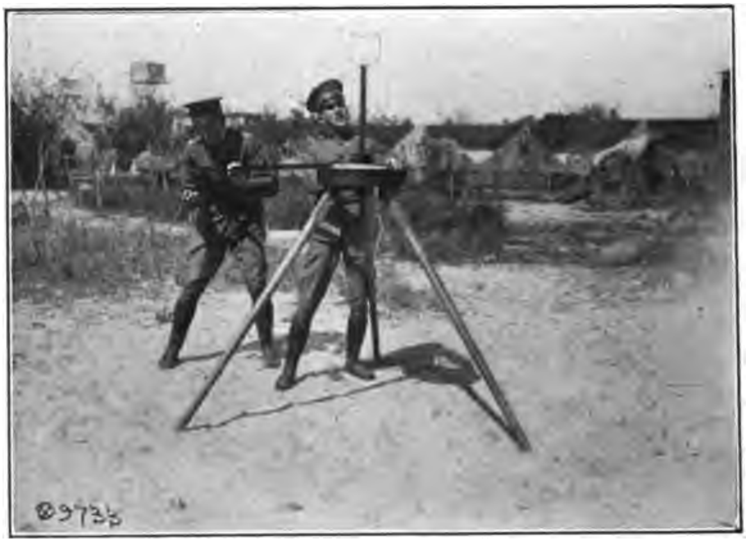
But little enough was said about either higher or lower mathematics. Faint-hearted students who sought to resign after the first plunge into Gunnery were restrained and reassured by being told that practically all the computations would be made mechanically and that a firm faith in "Right Raise and Left Lower" and such rules of thumb would pull them through in comfort.

Of the text-books mentioned, *Notes on Ballistics* consisted of two corrected reprints from the *Journal of the United States Artillery* for September-October, 1913 and January-February, 1915, "*High Angle Fire,*" by Major Alston Hamilton, C.A.C., and "*Direct Fire,*" by 1st Lieut. George A. Wildrick, C.A.C. *Gunnery Notes* was a pamphlet "assembled for use of the Artillery Section, Department of Enlisted Specialists, Coast Artillery School, and for the information of those desiring an elementary knowledge of gunnery." It dealt with ballistics and adjustment of fire for seacoast batteries.

THE PUFF BOARD 2229

The instructors gave prepared lectures and the students were expected to get what they could and preserve it in their note-books. One of these note-books shows that the course (then called Artillery, Gunnery and Ammunition) dealt at a great length with the fire control, firing data and range tables of the seacoast batteries, somewhat more briefly with ballistic theory, and rather seriously with powders, projectiles, primers, and fuses, included a pretty sample of optics and touched briefly on field guns and gunnery and the British grid artillery board and T-O-B clock.

"Before the Second Camp started some of the more valiant spirits who had just graduated into the ranks of officers: two lawyers, one salesman, two Democrats, and one Presbyterian, flanked by a group of college professors, took a special course in the 'art and science of handling guns' preparatory to assuming their arduous labors as Gunnery professors." In the meantime Captains Mather and Green had "hastily assembled from various sources" a pamphlet entitled *Reference Notes On Gunnery and Ammunition.*



TACHYSCOPE 2230

DETERMINING SPEED AND COURSE OF TARGET (ANTI-AIRCRAFT SCHOOL)

Various pamphlets from abroad on *Maps and Artillery Boards, Notes on the Employment of Artillery in Trench Fighting,* and *Notes on Fire Control Instruments for Use with Heavy and Railway Artillery* were included in the reading lessons.

Parallel to the course in Gunnery, and not very clearly separated from it, was a shorter course in "Artillery Defense and Fire Control and Direction" which consisted in the first camp of a generous dose of the War Game. In the second course there was added to this the T-A-B and T-O-B clocks, the elevation slide rule, and some of the tactics of heavy mobile artillery as contained in a translation from the French *Manual of Heavy Artillery* and from British sources.

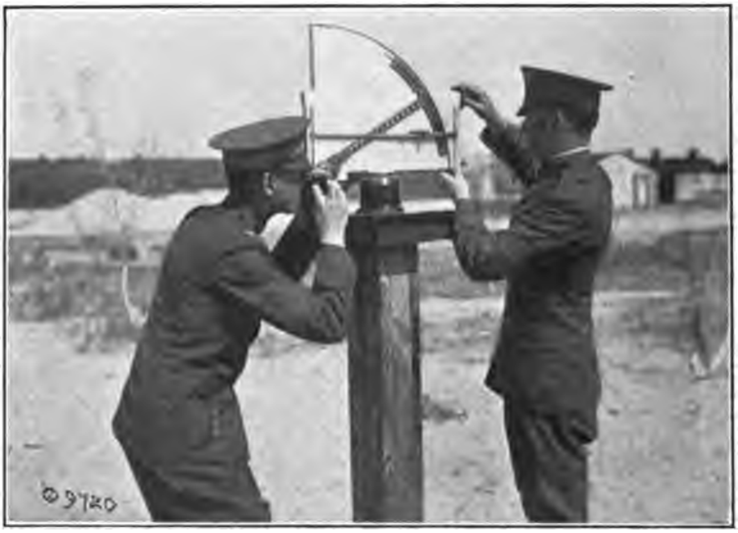
The Target-Aeroplane Battery was a British scheme for the observation of fire, based on the familiar clock-talk of the rifle range, with magnetic north as 12 o'clock. The T-O-B clock was a Coast Artillery invention to aid the B. C. in adjusting fire. Both were abandoned by the American Heavy artillery, but out of the T-O-B clock grew the system of unilateral observation which was being taught at the end of the war.

"As various professors of mathematics who had been so troublesome in the First Camp had been returned as instructors, the course began to see the introduction of some theoretical mathematics." In the Second and still more in the Third Camp "the lectures began to savor a little less of purely Coast Artillery gunnery and the influence of changed conditions in fire control and the computation of firing data was making itself felt." In the third camp a decided mathematical flavor was evident and such matter was taught as the co-operation of aircraft and artillery, ranging on the line of observation, location of the position of a battery, switching, field artillery ammunition and emplacements. "Western Front Methods and Matériel" was the subject of one lecture, with a reading lesson in *Field Artillery Notes.* Bulletins of the Heavy Artillery School of the A.E.F. on Gunnery and Fire Control, edited by Captains Shedd and Welshimer, began to arrive. "This was a transition period, when Coast Artillery methods were given the most prominence in the instruction because this was the tradition of the Coast Artillery, but where the rôle of heavy Artillery was fast assuming a prominence which in time eclipsed the seacoast methods of fire control and adjustment." The transition, to be sure, was considerably, if not abruptly, advanced by the return of Colonel Welshimer and General Sunderland from France in February.

During the first camp there were about forty one and one-half hour periods devoted to Gunnery; in the Second a slightly increased total allotment was given in 32 shell, 2-hour periods; in the third camp this was further increased to 52 shell, one and one-half hour periods—carrying the course through the whole camp.

In the general house-cleaning which took place before the Fourth Camp began, Gunnery lost a good deal of miscellaneous matter it had been carrying. "Matériel was teaching more theory of the whys and wherefores of such instruments of destruction as the Pratt Range Board and the Deflection

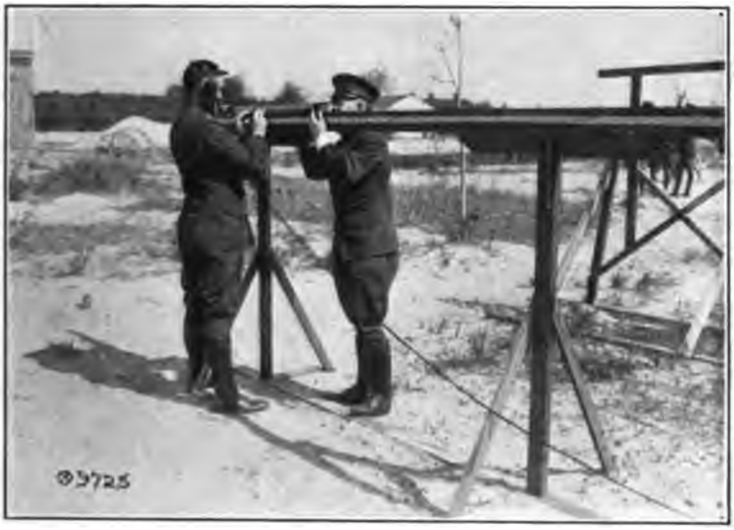
Board, the orientation and calibration of guns and mortars; Topography had taken over the subject of Seacoast Engineering and the construction and camouflage of emplacements; Optics was dropped from the schedule because of its minor importance, and now consists only in the statement that 'type E.E., Signal Corps, binoculars may be purchased from the Signal Corps (sometimes) for the necessary cash,' ammunition was presented to Matériel." Gunnery, pure and simple, assumed its place as one of the four major departments which were now organized.



TELEMETER 2231
EARLY TYPE (ANTI-AIRCRAFT SCHOOL)

On April 18 Captain Wildrick's compilation, *Gunnery for Heavy Artillery*, was published for the use of the Fourth Camp. The new course in Gunnery, postponed to the fifth week of the camp, ran for 72 hours of instruction, or until the end of the academic schedule. "Coast Artillery Gunnery had been relegated to a series of twelve mimeographed conferences and twelve lectures. These were used to start the course, and Gunnery for Heavy Artillery followed. Forms A and B of the Battery Sheet became the most important part of the course, for a time, with adjustment of fire running a close second. Mathematics was coming into its own. Ingalls' tables were used in the computations of range tables and double interpolation found many victims. The 155mm. G. P. Filloux gun range table was used as the basis of the course in Heavy Artillery methods. Probability of hitting was introduced."

The interval of several weeks between the course in the Fourth Camp and that in the Fifth was used to prepare an outline of instruction which for the first time made Gunnery as taught in all the sections a uniform course and this made standardized examinations possible. Gunnery was reduced to 68 hours, in compensation for which target practice was made an integral part of the course and placed in charge of the Gunnery Department. Liaison with the Army Heavy Artillery School in France was strengthened by the return of two instructors from overseas. In addition to the work with *Gunnery for Heavy Artillery* and *Coast Artillery Gunnery* a lecture was given, with a bulletin as reading assignment, in *Observation of Fire, Terrestrial and Aeroplane.* Methods of adjustment of fire were constantly changing, and with the return of still another instructor from France the subjects of unilateral adjustments, graphic record of shots, integral corrections on the salvo center of impact, and a murmur of high burst ranging were introduced. Further bulletins on observation were published.



STRING ALTIMETER (ANTI-AIRCRAFT SCHOOL) 2232

Range tables for various guns were computed by members of the Gunnery Department and distributed to all the Coast Defenses to play their part in introducing Heavy Artillery methods. Ingalls' Revised Ballistic Tables were used to compute various columns containing corrections for all the known variables of firing, and the idea of ballistic wind and Φ, X and V "relative to the wind" were introduced into the tables to the profound discomfiture of certain members of the instruction staff.

RANGE DISC 2233
SETTING SUPERELEVATION (ANTI-AIRCRAFT SCHOOL)

During the latter part of the Fifth Camp Major (then Captain) Englehardt and Captain Thomson were compiling the textbook now used in the course, *Heavy (Coast) Artillery Gunnery for Field Service*. This "contains the practical and theoretical principles underlying the calculation of firing data, the aiming and laying of guns, and the methods of adjustment and fire control." The book was a revision of *Gunnery for Heavy Artillery* in which several instructors of the Gunnery Department assisted. Parts of the 1918 revised edition of Ingalls' Ballistic Tables, including the Q method of determining range tables from proof-firings, and the Range Table for 10-inch seacoast gun on Railway mount, were included in an appendix. As the Gunnery Department had now taken over from Matériel the theoretical instruction in aiming and laying, a chapter on this subject was introduced, together with a chapter on Emergency Firing data and all the new methods of fire control so far as they were known at the Coast Artillery School up to September 1.

Three more instructors who had returned from overseas entered the department before Gunnery began in the Continuous Camp. The teaching staff enlarged to meet the new demands of a 3000 candidate camp, rose to the unheard of total of 54, though six instructors were soon detached for service as Heavy Artillery representatives with the Student Army Training Corps. The new schedule required four instructors to begin teaching every week in the Candidates' School, and two more in sections of the Aerial Observers' Course. "High burst ranging was assuming a major significance in observation and during November a bulletin on this subject was prepared which reviewed the two methods of tangent projection and tangent reticule observation. The course as finally standardized for companies taking the 12 weeks' Candidates' Course included 114 hours of "Theoretical Gunnery for Heavy Artillery," followed by 48 hours of Target Practice with Heavy Artillery.

The metamorphosis of the Coast Artillery Corps into the Heavy (Coast) Artillery has been paralleled by the development of the course in Gunnery from a few lectures on seacoast gunnery and exterior ballistics to a well co-ordinated presentation of all the theory and practice of heavy artillery in the field that could be gleaned from reports from the fighting in France. It was too much to hope that the course should keep fully abreast of the changing technique of the artillery overseas, but it was kept just as close to this limit of excellence as possible.

MATERIEL

This summary of the varied adventurers of the candidates with guns, mortars, howitzers, ammunition, aiming and laying, knots, gins, shears, and what not, broadly comprehended under the title of Matériel, is based on a history of the department prepared by Major William C. Foote, lately Senior Instructor.

During the first three camps the heterogeneous mass included in Matériel was presented in almost as many different courses as there were subjects. The Matériel department as such dates from the reorganization which took place between the Third and Fourth Camps. Furthermore, until the Fourth Camp Matériel meant seacoast and light field matériel—not from choice, but from necessity. No real heavy mobile pieces were available until the end of the Third Camp, and the present equipment was not fully assembled till the end of the Fifth Camp. The development of Matériel is thus a matter of selection and integration of subject-matter, on the one hand, and of hitching up the Coast Artillery Corps with Western Front conditions—the old story—on the other.

In the First Camp instruction was given by a few Regular Army officers with the help of experienced N.C.O's. One officer and two non-coms, for instance, handled fifty candidates at a time at Battery Church. The courses consisted of Major Caliber Seacoast Guns—nine daily periods of three hours each at a 10-inch or 12-inch disappearing carriage batteries; Seacoast Mortars—a like period at the 12-inch mortar pits; Field Artillery and Matériel—the U. S. 3-inch piece, B. C. instrument and range finders; Mechanical Maneuvers—9 hours; and Artillery Defense—The Coast Artillery War Game, which was as much Gunnery as Matériel. There was also a lecture or two on telephones and signalling and on gas engines.

The only texts available were a few C.A.D.R.'s, some Gunners' Instruction manuals, and handbooks of the 3-inch gun. One C.A.D.R. served a squad or more, fifty 3-inch gun handbooks had to do for the whole camp. Instruction in drill at the seacoast and field batteries was excellent. What was retained of the theory and detail depended upon the memory of the candidate and the notes he was able to make. Under the heading of Field Artillery were taught the T-O-B and T-A-B clocks and the Elevation Slide Rule, familiarly known as the "coffin-box." Mechanical maneuvers in the First Camp has already been described in an earlier page. So far as the new matériel was concerned, the lecturers in Gunnery enumerated them briefly in the course at one day's remarks; and an instructor in Matériel showed his classes drawings of a 14-inch rifle, which, he said, their grandchildren might be lucky enough to see.

During these first camps Gunnery and Matériel overlapped and cris-crossed with cheerful inconsequence. Instructors went from one to the other. Some subjects were taught by both departments. Nobody could tell where one left off and the other began. The only unmistakable fact was that neither of them had as yet gotten very far away from seacoast habits of thought and practice, but that both were groping through a maze of mixed British, French, and American methods toward the new technique.

After the First Camp a group of graduates selected to teach Matériel were given a month's intensive instruction in "Seacoast Artillery Matériel" under a Regular Army officer, and then turned about and drilled the Virginia National Guard Coast Artillery for a week. Both experiences helped to make them excellent instructors, and since the training camp idea was still fresh and the students were highly selected, the work at the batteries during these first camps has never been surpassed for smartness and energy.

ANTI-AIRCRAFT GUN SIGHT (ANTI-AIRCRAFT SCHOOL) 2234

In the Second Camp Matériel and related subjects were taught as follows:

Major Caliber Seacoast Guns	24 hours	(8 days)
Seacoast Mortars	24 hours	(8 days)
Mobile Artillery (matériel, drill, firing data, fire adjustment and control.)	30 hours	(10 days)
Mechanical Maneuvers	18 hours	(6 days)
Telephones and Signalling	12 hours	(8 days)
Artillery Defense (war game, fire control, maps and Artillery boards.)	24 hours	(16 days)

Mobile Artillery meant the 3-inch gun, and firing data, fire adjustment and control in this connection meant field artillery methods, so far as it did not mean simply a theoretical appendage of the drill. In Artillery Defense there was, as has been noted under Gunnery, some overseas matériel which included mostly methods and devices since scrapped.

In the Third Camp, which occupied fully three months instead of the two months into which the artillery instruction had been crowded in the First and Second Camps, the various Matériel courses were expanded, as follows:

Major Caliber Seacoast guns	39 hours (13 days)
Seacoast Mortars	39 hours (13 days)
Mobile Artillery and Firing Data	33 hours
Mechanical Maneuvers	21 hours
Telephones and Signalling	19½ hours
Artillery Defense and Fire Control and Direction	39 hours

The 2.95 mountain gun was the basis for the mobile artillery course. Artillery Defense, as in the previous camp, included the War Game and an increasing amount of overseas matter.

The arrival of the officers from France and the resultant revolution in instruction led to the scrapping of a good deal of this material. The War Game was dropped altogether. The "coffin-box" lost its significance when it appeared that computation must be done by the battery commander with his pencil and log tables, and not with mechanical devices. Matériel was moved forward so that all sections would see and drill with the major-caliber guns and mortars before tackling ballistic theory and firing data. The candidate had learned what "muzzle velocity," "deflection," and "drift," meant, and had seen corrections made for them at the plotting rooms. At the same time it was realized that the increasing emphasis on field methods and matériel must crowd out some of the sea-coast drill, and the courses at the batteries and mortar pits were cut down.

About two weeks before the end of the Third Camp two 6-inch wheel mount rifles and 2 Russian 8-inch howitzers, with a 240 mm. trench mortar, were received at Fort Monroe. Bulletins on the 6- and 8-inch pieces were prepared and mimeographed, and the instructors proceeded to master the new armament for the benefit of the candidates of the Fourth and later camps. Ammunition was taken over from the Gunnery course, "Mobile" Artillery became Heavy Mobile Artillery, and the field artillery fire control gave place to a more ambitious course in Aiming and Laying. In the Fourth Camp the schedule for Matériel, now taught by the newly organized department of that name, was as follows:

Seacoast Guns	21 hours	(7 days)
Seacoast Mortars	21 hours	(7 days)
Telephones and Signalling	6 hours	(2 days)
Mechanical Maneuvers	9 hours	(3 days)
8-inch Howitzer	15 hours,	3 periods of 3 hours each and 4 periods of 1½ hours each.
6-inch Gun	15 hours,	
Aiming and Laying	15 hours,	
Ammunition	9 hours	(3 days).
Total	111 hours	

ANTI-AIRCRAFT IMPROVISED COMPUTING DEVICES 2235
(ANTI-AIRCRAFT SCHOOL)

Seacoast artillery matériel began the course, then came mobile artillery, with ammunition in the last three days before target practice. In the new course in Aiming and Laying the department was really encroaching on fire control for mobile artillery, properly the field of the Gunnery Department, and indeed parallax was taught in both courses.

In the Fifth Camp this course in Aiming and Laying, spread out rather thinly over fourteen one and one-half periods, was given at the end of the course where it paralleled Gunnery. The seacoast batteries received still less time, 16 hours apiece for guns and mortars, the telephone and buzzer were eliminated, but ammunition continued to be taught in a fashion which made it an oasis in an arid desert. An hour and one-half of lecture and quiz, in this course, preceded an hour and one-half of written examination. The quiz invariably provided the attentive student with all the information he was asked to yield up in the examination, and more, and candidates whose nerves were rasped by army regulations and ballistic tables relaxed, leaned back, and smiled—and "pulled" 95 or 96 on the course. The total allotment for Matériel was 73 hours.

The Fourth and Fifth Camps are mainly distinguished by the uniformity in instruction made possible by the excellent organization, and the service of the Mimeograph, Blueprinting, and Drafting Departments. The number of drawings in use has constantly increased. During the first three camps instructors had to improvise sketches on the walls of the emplacements or on brown paper. With the establishment of the drafting and blueprinting service, a supply of blueprints, both colored and uncolored, was created and over 60 different drawings are now in use.

In the Continuous Camp the last step was taken in bringing together all the scattered courses of the Matériel Department. Previously some of them had been spread through the latter part of the camp, but in the new schedule the courses followed each other without interruption and the whole of Matériel was completed before the candidates passed on to Gunnery and Administration. The First four companies of the Continuous Camp took an abbreviated course in Matériel, with only five 4-hour periods on the seacoast guns and three on the mortars. The regular Matériel schedule for the 12-weeks' course was as follows:

Seacoast Guns	24 hours
Seacoast Mortars	20 hours
8-inch Howitzer	20 hours
Railroad Artillery, Mechanical Maneuvers, and 6-inch Gun	16 hours
Ammunition	14 hours
Total	94 hours

The most interesting change in the new schedule was the addition of a full course in drill as well as matériel of the 8-inch howitzer, which had taken its place as one of the most useful pieces fired by the Army Heavy Artillery in France. The appearance of Railroad Artillery in the course was made possible by the receipt of one 8-inch Railway Mount Gun and two 7-inch Navy guns, railway mount, just before the end of the Fifth Camp. The Navy guns were used merely for instruction in the preparation of railway mounts for opening fire. Firing spurs were built on the beach to illustrate the use of railway guns. Gunnery having assumed charge of the theoretical part of Aiming and Laying, Matériel confined itself to the mechanical details and practical handling of the panoramic sight, goniometer, aiming rule, etc.

THE GUN POINTER 2236

Beginning with Company K a slight modification was made in the schedule. One four-hour period was taken from Seacoast guns and added to the Railway guns, so that each of the four principal subdivisions of the course then began on a Monday and ended on a Friday. It will be observed that more than half the course was then devoted to heavy mobile artillery matériel and related matters. An unaccustomed spice was added to the course in Mechanical Maneuvers by dismounting some of the old field and siege pieces and burying others in pits to give candidates an opportunity to do their own hoisting and mounting.

As its apogee the Department of Matériel claimed a total of 57 instructors. These, of course, began to fall away as the

Continuous Camp reached its climax and went into its early decline. The organization of instructors in "teams" each in charge of a sub-course made their work particularly effective during the Continuous Camp.

No single text-book covering the subject matter of Matériel has been published. Ordnance pamphlets and mimeographed bulletins have been used, together with the C.A.D.R. and *Gunners' Instructions.* A pamphlet on Ammunition was published; one on the matériel of Aiming and Laying was prepared. A textbook on seacoast matériel and the 8-inch howitzer is in process of preparation.

In the Continuous Camp the matériel available for instruction included the following:

2 batteries 12-inch Rifles, disappearing carriage, with fire control apparatus.
2 batteries 12-inch mortars, with fire control apparatus.
1 battery 8-inch howitzers, with communication outfit, sighting targets, etc.
2 6-inch wheel-mount guns.
1 8-inch Railway Mount Gun.
2 7-inch railway mount Navy guns.
1 9.45 trench mortar.
2 2.95 mountain guns.
Ammunition cars for railway guns.
Aiming rules, French goniometers, U. S. panoramic sights, gunners quadrants..
Gins, shears, etc.

For use in mechanical maneuvers:

1 muzzle loading cannon.
1 3.2 field gun.
1 5-inch seige gun.
1 7-inch seige howitzer.

ORIENTATION

No other course in the training camp grew as quickly or suffered as many changes in terminology as Orientation. It began as a brief, unassuming affair that looked for its origins chiefly to the Master Gunner course, it grew to be second only to Gunnery in importance and fully its equal in awe-inspiring prestige. Those candidates who took the last two weeks of Orientation and the first two weeks in Gunnery simultaneously acquired a profound respect for both courses—if they survived to have any opinion at all.

The First Camp devoted a grand total of nine hours to

Maps and Field Fortifications. Three hours sufficed for a plane table traverse and three point problem; three more for map reading, profiling, and contour study from the honorable Gettysburg maps; three more were given to staking out trench "traces" and the consideration of field fortifications. The candidates worked their plane tables around the little park by the dock; their peaceful horizon was bounded by the Commandant's house on one side, the Chamberlin Hotel on another, and the gentle surf of Hampton Roads on the third. But on some sections, including that which claimed the Senior Instructor of later courses, it "rained blue blazes." There was no digging in field fortifications, and nothing said of camouflage though some interesting experiments in this art accompanied target practice. Some twelve traverse boards serving for plane tables were the beginning and end of the available equipment. There was a textbook: *Spaulding's Training Manual in Topography, Map Reading and Reconnaissance.* Griggs' *Map Reading and Sketching*, also recommended, proved to have interesting ballistic qualities as a squadroom missile. The instructors were one first lieutenant and two master gunners.

Telephone Detail 2237

In the Second Camp Map Reading and Field Fortification had grown a little. It now commanded a total of 26 hours, 20 for the first part of its title, 6 for the second. In Map Reading ten hours were given to the study of map scales, conventional signs (in all seriousness), contouring, and profiling. British battle-maps made their appearance, and while it was only a trace, there *was* a trace of overseas matériel, from British sources. At least the course had gotten away from the traditional Gettysburg area. Six hours were devoted to the plane table. The traverse parties left the park and took to the parapet. Only graphic solutions of the three-point problem were attempted. Four hours were claimed by the transit, now that three instruments had been acquired in addition to the 25 traverse boards that were now on hand.

By the Third Camp the rapidly growing course had acquired a middle name and gained half its former length. Map Reading, Sketching, and Field Fortifications was assigned thirteen periods of three hours each. The serious introduction of the transit as an instrument of triangulation (the traverse was not yet taught) was the principal change in the course as it was given in the first part of the camp to half the sections. Twenty-seven hours belonged to map reading and plane table traverses, laying out a base line and simple triangulation problems with the transit, and the British firing board (which was only a step removed from the Coast Artillery plotting board). Four hours were devoted to field fortifications.

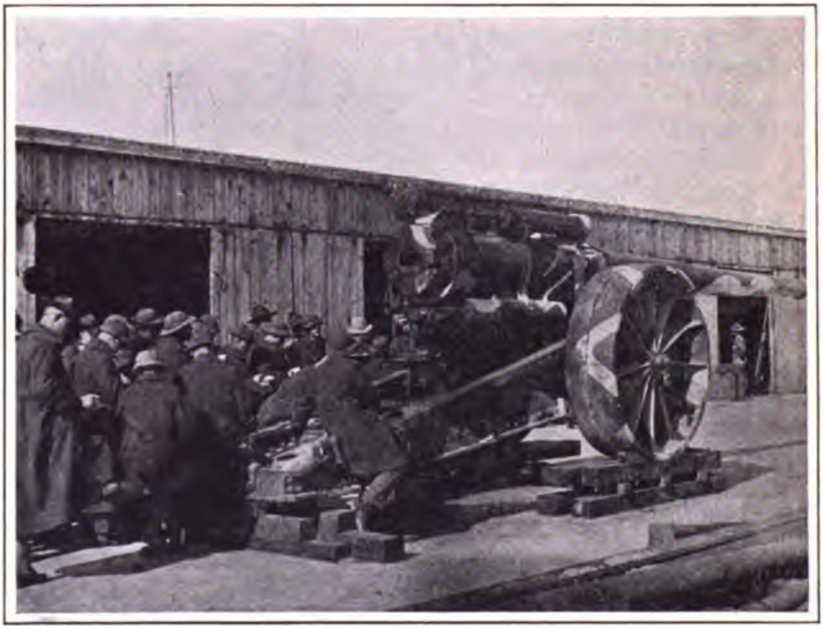
This course was nearing completion for the half of the camp that happened to have it first (under the rotary system then in force) when the arrival of Colonel Welshimer and General Sunderland released a quantity of new material which added tremendously to the stock of technical information which could and must be taught to officer candidates who expected to serve batteries in France. The department had already been struggling with atrocious translations of French orientation manuals—translations which effectively camouflaged the methods of the orienteur. Now that accurate and negotiable information was ready for use, however, the instructors put over the most rapid adjustment of fire ever seen in the training camp. They whipped the new matter into shape for immediate consumption and interjected twelve one hour lectures into the middle of the camp, by means of which the gist of the French system was at once passed on to the cadidates who had already completed the existing course. The *Manual* *for the Artillery Orientation Officer*, extracts in translation from the *Manual de l'Officer Orienteur d'Artillerie*, covering both orientation and firing computations, was distributed as far as the supply went—about two to a squad. The Lambert projection and quadrilage and related material were thus added to the stock in trade of the candidates, and the instructors proceeded to mull over relévement and the United States method of resection in preparation for later classes.

Since it was now decided that Orientation, or Topography as the Fourth Camp called it, should parallel Matériel as the introductory part of the curriculum, preceding Gunnery, the instruction staff had no such convenient interval to reorganize their course as the teachers of Gunnery enjoyed. With the beginning of the Fourth Camp the new course was ready. Liberal use of the mimeograph and the publication of copies of the Vailly square of the French battle maps supplemented the available texts for the time being, and Major Walton C. Clark, (then Captain) was at work upon a text-book which should gather up the old and new material in convenient form. Twenty-three days, with three hours each, were given to topography; four more to field fortification, making a total of 81 hours. The equipment for field work had been increased to 17 transits, 50 plane tables, and 25 traverse boards. Topography, French cartography and quadrillage traverses and triangulation, intersection and resection, with all the new methods, topographic reconnaissance panoramic sketching and orientation for railway artillery made up the new course. Field Fortifications took unto itself a lecture on camouflage and "field work," which was accomplished with spade and sand-bag on the beach, where an elaborate battery position was laid out.

Orientation for Heavy Artillery, fresh from the presses, was ready for the Fifth Camp. Aside from a somewhat fuller treatment of certain subjects, quadrillage, meridian determination, etc., the material thus made available for study was not very different from what had been used in the Fourth Camp. The course as a whole grew a little; orientation proper gained six hours and field fortifications lost three, making the net total 84 hours. The instruction staff was increased to 20; the transits to 40.

To keep pace with the Continuous Camp the department more than doubled its staff after the Fifth Camp, reaching a maximum of 48 instructors, and put out a revised edition of its text-book. The new version shows a number of improved diagrams, the Italian method has been added to the graphical solutions of the three-point problem and the text has been strengthened here and there throughout the book. Ninety-five transits and 100 plane tables were on hand, which insured an ample supply of equipment for the Continuous Camp.

When the new French methods were first brought to the School, it was specifically ordered that existing French terms should be used. Gisement, Jeesmo, Gueesmong, Jeesmawnt, and half a dozen other variations of that intriging term were accordingly current in section-rooms and barracks during the Fourth and Fifth Camps.



Department of Enlisted Specialists, C. A. S.

STUDYING A 6-INCH GUN AT CLOSE RANGE 2238

The three non-descript dogs which frequented the parade ground escaped with the names of "Wind," "Drift," and "Travel," but more than one instructor would have been surprised to hear the highly technical Gallic terms which the classroom jargon fastened on him behind his back. Candidates prattled of True, Magnetic, and "Grid" north and occasionally, in Gunnery, one who was especially bold would venture on

Coup de flambage. Essai fire and amelioration fire became commonplace.

But while the whole-hearted acceptance of French technique, to the exclusion of the British precedents which had flavored the early camps, was in no way altered, the Heavy Artillery School of the American E. F. eventually rebelled against this French terminology. Accordingly a bulletin issued shortly before the end of the Fifth Camp prescribed that certain new American terms should replace the familiar French ones.

Consequently gisement became Y-azimuth, grid north became y-north, and only relévement (alias revelment) remained to try the tongues of candidates and those who had once been candidates.

Tactical Training

In spite of the fact that the candidates of the First and Second Camp came to Fort Monroe with a month's intensive infantry training behind them, a daily period of infantry drill, with frequent parades in addition, was a fixed feature of the schedule in each training camp. For several camps it was customary to call a candidate out without warning to take any command from platoon leader to battalion adjutant. On the basis of his performance, in large measure, depended his "company mark"—that most mysterious and most feared rating which the company commander and his lieutenants were charged with determining. Later this ordeal was mitigated by announcing beforehand what candidates were to command. During the first five camps the company mark was given on a percentage basis, physical qualities, aptitude, military leadership, and character being given equal weight, together with a mark for education and one for occupation which were assigned by the School headquarters. Beginning with the Continuous Camp the Scott system of rating, as prescribed for all officers, was adopted for candidates as well.

The partial use of the rifle in the Fourth Camp and the arming of all candidates in the Fifth Camp have already been noticed. In the Continuous Camp this instruction was to be carried to its logical conclusion, and each company was to have some training on the rifle range, but this plan, like the projected guard duty which all candidates were to perform for training purposes, fell by the wayside when the camp came to a halt. But the candidates could sing—and sing they did.

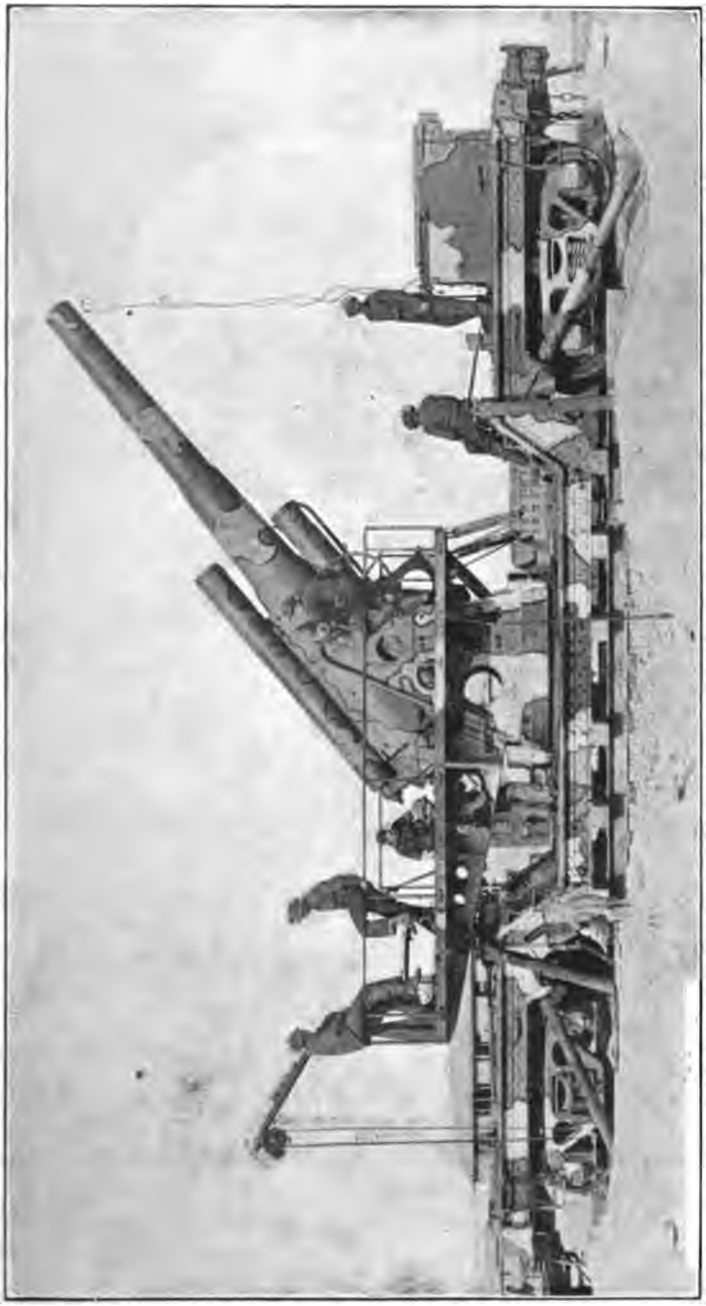
The training camp inspections—who cares to recall these?

Long before one reached Fort Monroe, their fame reached the prospective candidate, to wither his hopes. Graduates who had not been overly attentive to the dust rag enlarged upon the subject; they carried to the defenses harrowing tales of the way in which inspecting officers would drag a white finger at random around locker or bed or floor or ceiling and then condemn the candidate whose possessions were found anything less than immaculate, to grievous penalties. When one actually arrived, he discovered that while it was in truth wearisome to fold one's mattress, sheets, and blankets, line up one's pillows, sweep one's section of floor, dust one's cot and locker inside and out and on top, and wipe off one's locker trunk for the fortieth time, every morning for three months, it did become possible after practice to do all these things before the bell rang and still have time for a hasty glance at administration or a meditative cigarette on the barrack porch. And he discovered further that the vagaries of the breeze in the squadroom often undid his most earnest labors, and that in the long run the "skin" lists reflected meteorological conditions quite as accurately as character, and unless one was very unfortunate, or very wicked, it was not necessary to take them too seriously.

GAS DEFENSE

No course which attempted to fit men for overseas service could omit instruction in gas defense. Accordingly the Gas Defense Division of the Chemical Warfare Service established itself at Fort Monroe in March 1918, and commenced to give candidates, officers, and the regular troops of the defenses necessary drill with the small-box respirator and lectures on the use of gas and the practice of all known defensive measures.

For men in the training camp this took the form of a five-day course, later given in three days, which involved enough drill with the respirator so that every candidate could pass a time-test for rapid adjustment and could safely be put through "gas demonstration" which included exposure to lachrymatory gas, a concentration of chlorine sufficient to cause death in five minutes, and a series of outdoor "gas attacks."



Department of Enlisted Specialists, C.A.S.

8-INCH RAILWAY MOUNT

2229

ADVANCED AND SPECIAL COURSES

During the war the biggest task Fort Monroe has been called upon to do has been the training of new officers. But it is clear enough that if the course for candidates changed so radically in the course of a year and a half, there must have been many officers with only the old coast artillery training behind them who needed quite as much as the candidates to be acquainted with the new overseas technique.

For their benefit a series of "basic courses" were given by the Coast Artillery School after the regular Officers' Course had been suspended. These courses ran from six to eight weeks, and gave the students approximately the equivalent of the gunnery, heavy mobile matériel, and orientation which the candidates were learning. The first course was begun in January; by September all the officers then available for instruction had received some such training and the courses were therefore discontinued. They were given as follows:

		Under Instruction	Passed
1st course	January 5 to February 23, 1918.	300	169
2nd course	March 2 to April 20, 1918.	150	95
3rd course	May 4 to June 29, 1918.	150	97
4th course	July 8 to September 6, 1918.	150	106
	Total	750	467

The outline of the course, as it finally took shape, is given below:

	Hours
Gunnery	130
Orientation and Field Fortification	88
Matériel	42
Gas	14
Target Practice	25
	299

Since the officers who took this course were thoroughly familiar with the ordinary fire control systems in use in the Coast Artillery it was necessary only to relate the new methods to what they already knew. A great deal of time could be given to adjustment of fire, and out of this intensive study developed the "puff board" and the "dispersion board" with its associate the "hit bag." The "puff board" is a miniature terrain on which typical targets are indicated, so constructed that puffs of ammonium chloride can be blown at any desired point to represent the explosion of a shell. It was used in giving candidates a final drill in methods of observation and adjustment. The "dispersion board" and the "hit bag," in which the theory of probability is given an engaging demonstration and adjustment takes a pleasantly graphic form, proved tremendously entertaining in the classroom, and candidates sometimes had to be dissuaded from gambling away their study-hours with it.

AERIAL OBSERVERS

The plan first adopted to secure aerial observers who should be sufficiently familiar with artillery practice to be successful in the air, was to detail a certain number of graduates of the training camp, already commissioned, to Langley Field for training in observation. During the Fifth Camp the increasing need for officers of this class—as of all others—led to a new plan, which brought to Fort Monroe from the Ground Schools of Aviation, cadets who were in the middle of their training as aviators. Here they were given a seven weeks' course with a very liberal share of Gunnery, some Matériel and Orientation, with Gas Defense and Target Practice. The purpose of this course was "to give the student a *consciousness* of the artilleryman's problems rather than a working knowledge of them." After the completion of the work at Fort Monroe the cadets were sent on to a flying field to be trained in the air as observers. The great difficulty with the course, from the student's standpoint, was that the promised commissions for which they were training proved to be more elusive than any camouflaged battery in France. The course, in outline, was as follows:

	Hours
Gunnery	118
Orientation	45
Matériel	40
Target Practice	24
Gas Defense	12
	239

When the Continuous Camp began, part of the plan was that a detachment of 50 aviation cadets should be attached to each of the training companies. During October the white hat-band, which had been rather a curiosity inside the Old Fort during the summer, became a very familiar sight.

ADVANCED ORIENTATION COURSE

All the candidates who went through the training camp after the Third Camp knew something of the topographical processes which a battery officer might be called upon to use in the absence of the battalion orienteur. But a man unfamiliar with transits can not get much facility in a few afternoon's squad practice, and the real work of orientation with the armies in France demanded better qualified men than the average graduate.

Experienced surveyors and engineers were accordingly assigned to a special course in Advanced Orientation which was inaugurated on July 8, 1918, with twenty student officers. It was an eight weeks' course, half given at Fort Monroe and half (because of the exceeding flatness of Old Point Comfort) at Charlottesville, Virginia, where real topography was to be found. Most of the work was given in the field, in the form of practical problems, which included all the ordinary tasks of the orienteur and gave the student a critical, comparative knowledge of all the methods in use for performing those tasks.

A second group of nineteen students began this course on September 23, 1918; a third group of forty on October 7. In the Continuous Camp it was planned to detail eight graduates from every company to Advance Orientation, but the suspension of the plan came too soon for this to be put into effect.

ANTI-AIRCRAFT ARTILLERY COURSE

Pending the establishment of an anti-aircraft artillery school at the School of Fire at Camp Eustis (which would make a story in itself), a series of five weeks' courses have been given in this arm of the service, at Fort Monroe. The first class of twenty officers began work in February, 1918. The function of the school was to prepare its students for service in the line so far as that was possible with the matériel available in this country; it was expected that they would take a further course at the American Anti-aircraft School in France, but that this course could be shortened because the fundamental instruction was given here. Three officers have been sent back to Fort Monroe, from the A. E. F. each each month, to insure teaching of thoroughly up-to-date methods, three others being released from the teaching staff here to overseas units.

The student officers in this course were picked for special technical qualifications. The course covered these subjects:

- Anti-aircraft Artillery.
  - Day fire control.
  - Night fire control.
  - Listening apparatus.
  - Searchlights.
- Aeroplanes.
  - Characteristics.
  - Methods of identification.
  - Enemy types.
- Field Service.
  - Selection of battery positions.
  - Defensive observation balloons.
  - Dugouts and emplacements.
  - Defense of cities, ammunition dumps and back areas.
  - Camouflage.
  - Pompoms.
  - Balloons
  - Smoke screens.
  - Light barrages.

Practical problems were worked out in the course, and a good deal of firing was done with the anti-aircraft gun on the beach. Watching for the bursts became a favorite sport of the training camp. On the completion of the course, according to an official statement, the officer was equipped "to devise, improvise, and operate sufficient fire control apparatus to enable him to take charge immediately of an anti-aircraft battery."

V

Barracks and Fills

This section is base on a statement kindly prepared by Major Arthur H. Lloyd, Engineer Corps, who has been in charge of construction at Fort Monroe).

It is hardly to be expected that Fort Monroe would accommodate comfortably these unprecedented thousands of students, together with its usual garrison and staff. In the autumn of 1917 it was decided to build temporary buildings to house the work and workers at the Fort during the war. A project involving forty buildings of standard cantonment types was prepared and the constructing quartermaster was authorized to proceed with the work about November 1.

It was necessary not only to put up barracks and quarters for large numbers of men and officers, but to increase the water supply, sewer capacity, lighting plant, and the post railroad. The urgent necessity for rapid construction was well understood, and every effort was made to complete the buildings in the shortest possible time. Contracts were quickly executed, material ordered, and the work pushed to the limit, with the result that in less than three weeks candidates were established comfortably in buildings constructed of lumber which was actually growing in the forest not much more than a month before.

It soon became evident that this project alone would not meet the requirements of the situatuion. The classroom of the Coast Artillery School had ordinarily been used by not more than forty students in the course of a year; now candidates were enrolled by the thousand. Authorizations for additional accommodations followed each other in rapid succession until a total of twenty-one were received, calling for the erection of about 250 different buildings. These included schoolroom buildings—the familiar double-decked section-room unit and barracks, messes, officers' quarters, latrines and warehouses. The type of building depended largely upon individual requirements and nearly twenty different designs were finally adopted.

Odd corners of the reservation were soon occupied by two story shacks of unpainted wood, set this way and that, wherever room could be found for them. Down the beach toward Buckroe crept the outposts, with barrack units, gun sheds, gas-houses and the like flanking the concrete road, and in the intervals between them, officers' quarters squatting bungalow fashion on the seaward side, making a brave attempt to look homelike between the truck trains and the railroad track.

Early in 1918 it became clear that there was actually not enough ground at Fort Monroe to accommodate the buildings which would be necessary. The only thing to do was to make more. Accordingly a fill was planned in the vicinity of the causeway on the edge of Mill Creek. Sand from the Bay was pumped into the marsh from the intake of the moat to a point close to the end of the trestle across the creek, the outer boundary of the area being bulkheaded in a more or less temporary manner to prevent excessive spreading of the dredgings. On the land thus reclaimed, barrack units and study halls were erected for the companies of the Continuous

Camp, which very soon overflowed the barracks within the Old Fort which had sufficed for the earlier camps.

The area of Fort Monroe was further increased by a fill between the railroad trestles back of St. Mary's Catholic Church, devoted to the use of the Enlisted Men's Department. The two fills together added to the post an area equal to about twenty-five acres. Nearly four thousand cubic yards of material had to be moved for this purpose.

On November 11 orders were received to suspend all operations, and work was practically stopped on the following day. The job had been complicated by the fact that unskilled and skilled labor had to be brought daily from Hampton and Phoebus, which put a considerable strain on the limited transportation facilities and made it impossible to place a sufficient force on the work to complete it in record breaking time. The figures representing the work done are, of course, small beside some of the other operations conducted by the Construction Division.

But during the entire period of war construction at Fort Monroe one building for every working day was completed and ready for occupancy. During the last month the work went at top speed and two buildings for each working day were made ready.

Five million feet of lumber was used, and over six thousand squares of roofing. The lumber consumed—270 full carloads, if carried in one train would require a train more than two miles long. If all the buildings put up at Fort Monroe during the war were thrown into one, that one would be about three miles long.

Department of Enlisted Specialists, C. A. S.

ASSEMBLY HALL

2240

ENLISTED MEN'S DEPARTMENT

By Lieutenant Colonel R. P. Hall, C. A.

April 16, 1917 found this branch of the Coast Artillery School with the Artillery, Clerical, and Electrical classes pursuing their regular eleven month courses and the Radio class its regular six month course. There were approximately one hundred and thirty students in the four courses. This was about the largest enrollment that this Department had ever had and was of such a size that all the books and apparatus were being used to full capacity.

As early as the middle of February this Department had taken up the question of whether, in an emergency, its courses could be reduced and it had been decided that due to the scope of the courses it would be impossible to cover the ground in less time than the usual period unless the mental qualifications for entrance were raised. New three month and six month schedules had been prepared by the Senior Instructors in each course basing each shorter course on students entering with more preparation so that the high standard of the graduates of the Department would not be lowered.

Early in May a letter from the Office of the Chief of the Coast Artillery Corps suggested that as there would be many vacancies among the non-commissioned staff due to many of the staff accepting commissions for the emergency that:

1. The present classes in the School be graduated as soon as they were fully qualified for temporary appointments.

2. That the vacancies at the School caused by these temporary appointments be filled by qualified men.

It was further suggested that perhaps specialists for the Coast Artillery Corps could be made direct from civilian life. Immediately the Department sent forward the schedules for shorter courses and recommendations for graduating the present classes at the end of an intensive twelve week period and starting larger emergency classes of either three or six months duration.

On May 14 the men in all the regular courses except Radio were started on re-adjusted schedules so that they could be graduated at the end of another twelve weeks. The

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*Prepared under supervision of Colonel Eugene Reybold, C. A., Director

Radio course continued its regular six months course graduating classes of fourteen men on June 15, and twenty men on November 13, and a special class of thirteen advanced students on September 17. With the emergency courses starting about the middle of November 1917 the Radio course started in on twelve weeks emergency classes in step with the other branches of the Department. On August 3, 1917, the following numbers of men were graduated with permanent warrants:

Artillery	13
Clerical	21
Electrical	42

RADIO INSTRUCTION 2241

The following letter from the Chief of the Coast Artillery to the Adjutant General of the Army and its indorsements started the training of enlisted specialists at five separate Schools:

May 23, 1917.

From: Chief of Coast Artillery.

To: The Adjutant General.

Subject: Temporary N.C.S.O., C.A.C.

1. In connection with letter of this office dated May 18, 1917, (O.C.C.A. 4489/187), it is recommended that the following instructions be communicated to the Commanding Generals, Northeastern, Eastern, Southeastern Western, Hawiian, and Philippine Departments:-

(a) In order to qualify enlisted men who are now in the Coast Artillery Corps, or civilians who enlist in the Coast Artillery Corps for the period of the war, to fill temporary vacancies caused by the temporary detachment of enlisted specialists to the Officers' Reserve Corps or as temporary officers, the following procedure will be adopted:-

I. Department commanders will cause information to be disseminated as to the qualifications that temporary appointees must possess to discharge their duties as temporary specialists, the service they will be re-required to perform, the pay and allowances of each grade, and such other information as may be of general interest to prospective candidates. This information will be sent to all coast defense commands, to technical schools, and colleges, and to electrical or other manufacturing establishments which offer promising material for the electrical and mechanical grades in the Coast Artillery Corps.

II. Efforts will be made to obtain qualified civilians by enlistment in the Coast Artillery Corps for the period of the war. These men should be informed that they should make application for attendance at the schools for the instruction of candidates for temporary appointments as enlisted specialists to department commanders of the departments in whose geographical limits they are located. These applications will be forwarded to the commandants of the schools designated below, who will examine carefully the papers, and decide whether or not a candidate will be admitted to the school.

III. Upon notification that the candidate is successful in his examination, and eligible for admission to the school, he will, upon enlistment, be ordered by the department commander to report to the commandant of the school for the course of instruction. If he successfully completes the three months' course of instruction, he will be eligible for temporary appointment as an enlisted specialist.

IV. In a similar manner, enlisted men of the Coast Artillery Corps will be given an opportunity to apply for this course.

V. The necessary travel orders will be issued by department commanders.

VI. The commanding officers of these training schools, upon the completion of the course of instruction, will arrange the successful candidates for each grade on one list according to merit, based on their practical and theoretical work during the school course. These lists will be forwarded at once to the Adjutant General of the Army.

VII. The temporary appointments will be made by the Secretary of War. When department commanders receive notification that successful candidates have been given temporary warrants, they will cause these temporary specialists to be assigned to duty in their departments upon the recommendations of Coast Artillery district commanders.

VIII. Men accepting temporary positions as specialists will be informed that the tenure of these positions will be limited to the existing emergency; and that upon the return of the permanent appointees to occupy the permanent positions after the existing emergency shall have terminated, they will be placed on the list of eligible candidates from which vacancies in the permanent list of specialists which may have occurerd during the emergency, or which may occur after the emergency, will be filled, provided their services have been satisfactory as temporary appointees.

(b) Schools will be established at the following places:

Fort Monroe, Va., for the Northeastern, Eastern (except Panama), and Southeastern Departments,—to be commanded by the Commanding Officer, C.D. of Chesapeake Bay;
Ft. Winfield Scott, Cal., for the Western Department,—to be commanded by the Commanding Officer, Coast Defenses of San Francisco;
Fort Kamehameha, H. T., for the Hawiian Department,—to be commanded by the Commanding Officer, Coast Defenses of Oahu;
Fort Mills, P. I., for the Philippine Department,—to be commanded by the Commanding General, Coast Defenses of Manila and Subic Bays;
Fort Grant, C. Z., for the Panama Coast Artillery District,—to be commanded by the Commanding Officer, Coast Defenses of Balboa.

Department of Enlisted Specialists, C. A. S.

A FLEET OF TRUCKS DRIVEN BY MOTOR TRANSPORT STUDENTS 2242

2. Department commanders should be informed that they may use any method of advertising or dissemination of information that they may deem advisable, in securing applicants for these special courses. Undoubtedly, there are many electrical and mechanical experts in civil life who could take up the work of specialists in the Coast Artillery Corps very promptly, and who would be glad to do so for the period of the existing emergency.

3. The course of instruction should begin on June 25, 1917, or as soon thereafter as practicable, and should continue for three months. The general course of instruction is indicated on the inclosed schedule. The course of instruction should be carried on by the method which is known as "in-

tensive training," with suitable intervals for recreation. For those candidates who are from civil life, suitable courses in general military training and physical exercises should be given, in addition to technical work.

4. These courses will be used as general guides in the instruction of candidates, but these men may be graduated from any course at any time that they may demonstrate their ability to perform the duties of their grade.

5. In connection with information that should be dissiminated as indicated herein, there is inclosed herewith a pamphlet compiled at the Coast Artillery School, giving information pertaining to appointments, promotions, duties, and rates of pay of non-commissioned staff officers, Coast Artillery Corps.

E. M. WEAVER.

On copy of
2599872 1st Ind.
War Dept., A.G.O., June 29, 1917—To the Commanding General, Eastern Department.

1. The Chief of Coast Artillery has been authorized to issue, for the period of the emergency, limited warrants in the grades of non-commissioned staff officers named in the first sentence of paragraph 310, Army Regulations. Enlisted men to whom such limited warrants are issued will be informed that if men formerly holding permanent warrants in such grades, who have been discharged to accept commissions in the Officers' Reserve Corps, the National Guard, the temporary forces organized under the Act approved May 18, 1917, or temporary commissions in the Regular Army, do reenlist in the Coast Artillery Corps, a corresponding number of limited warrants will be revoked, the men whose warrants are revoked being placed on the list of eligible candidates to whom permanent warrants may be issued in the order of their eligibility.

2. The recommendations of the Chief of Coast Artillery in his letter of May 23, 1917, copy of which is inclosed herewith, are approved, with the exception that limited warrants will be issued instead of temporary warrants, and the specialists referred to herein are the non-commissioned staff officers named in the first sentence of paragraph 310, Army Regulations. You will issue such orders as are necessary to give effect to the policy recommended by the Chief of Coast Artillery and approved by the Secretary of War.

By order of the SECRETARY OF WAR
(Sgd.) EDWARD T. DONELLY
Adjutant General.

(Copy of 2606974, with 2 incls. acpg.)
3 Incls.
352.16 C. A. C. School.

HDQRS. EASTERN DEPT., July 9, 1917. To Commandant, Coast Artillery School Ft. Monroe, Va., (thru Comdg. General, Middle Atlantic Coast Artillery Dist.) for his information. The dissemination of the information herein directed is being accomplished by these headquarters. Early return of these papers is requested.

BY command of MAJOR GENERAL BELL:
A. B. GARDNER,
Adjutant General
Adjutant.

Department of Enlisted Specialists, C. A. S.

NEW ELECTRICAL LABORATORY

2743

Schools were started in accordance with the above order but due to the school at Fort Monroe having the regular classes on hand it was necessary to graduate them first in order to make room for the new classes. A campaign by means of circulars and bulletins was at once started not only among all the colleges and technical schools where much excellent material for the department was to be found but also through many daily papers throughout the country at large so that in a very short time the department was receiving large numbers of applications for our first emergency courses. Each application contained a full statement of the candidates' qualifications and each was acted on individually by the Director of the department and the Senior Instructor of the course applied for. In this way very few men were accepted for the courses who were not mentally qualified to successfully complete them and the department owes the large percentage of graduates compared to the number entering, to this careful selection. Each applicant was at once notified whether he was accepted or rejected and the men accepted were told when and where

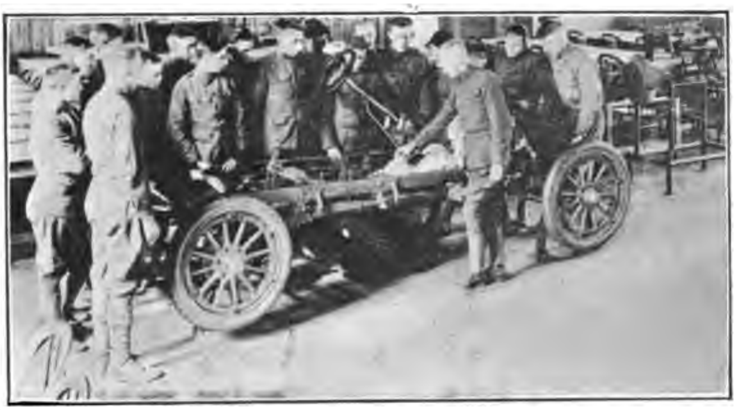
Department of Enlisted Specialists, C. A. S.

A MOBILE SEARCHLIGHT USED IN THE ELECTRICAL COURSE 244 to report. Due to the great need for trained soldiers in all branches of the service after the first emergency courses practically all students were men who had come into the service for the emergency.

The first emergency classes graduated the following numbers of men on November 13, 1917.

Artillery	31
Clerical	52
Electrical	74

About the last of September the four other schools designated in the above letter graduated classes of enlisted specialists and these men were given their warrants on a list mixed among the graduates of the first emergency classes from this department. However, it had been found out that due to the lack of proper non-commissioned staff officers for instructors in these other schools and due to the lack of books and apparatus that a better plan would be to use these four schools as preparatory schools and when the men in these schools had reached the proper degree of proficiency to send them to this department for the final training. During the following year these schools acted as preparatory schools and sent much of the best material to our courses. About September 1918 the school in the Panama Coast Artillery District was closed, and the school in the Coast Defenses of Oahu was combined with the one in the Coast Defenses of San Francisco, while this last named school was expanded largely in order that it might furnish a large neucleus for the classes in this department in



Department [illegible]

LABORATORY INSTRUCTION

2245

its largest program. The work of all the preparatory schools was excellent throughout the emergency and special credit is due to the one in the Coast Defenses of San Francisco.

The second emergency courses graduated the following numbers of men about February 27, 1918.

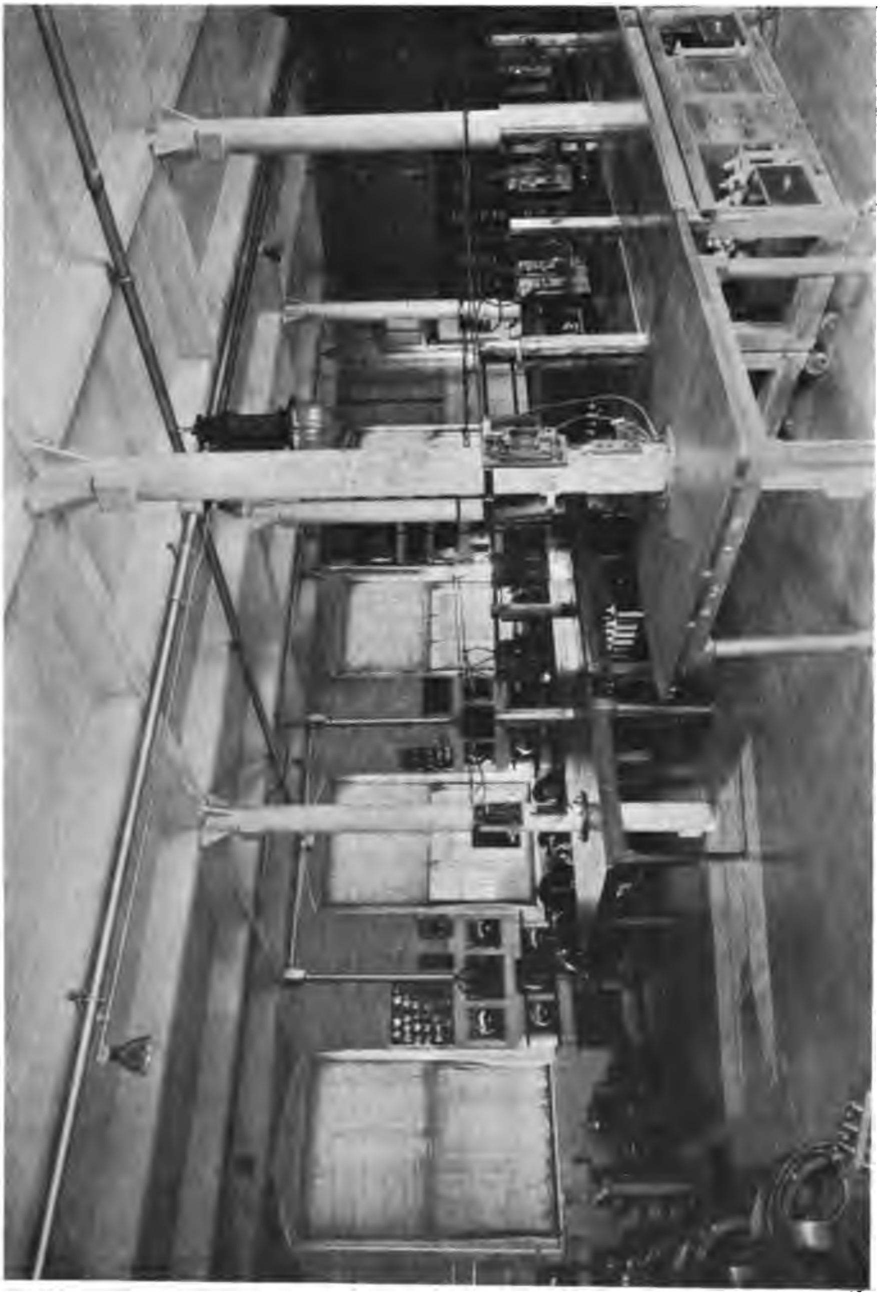
Artillery	36
Clerical	58
Electrical	100
Radio	32

The third emergency courses graduated the following numbers of men about June 17, 1918.

Artillery	46
Clerical	79
Electrical	107
Radio	58

On July 10, 1918, the Electrical course graduated ninteeen men and on July 17, 1918, the Artillery course graduated twenty-one men. This was due to the great demand for enlisted specialists at this time to complete the new regiments which were forming and the department was able to graduate these men earlier than usual by enlarging the classes and making the maximum use of all material.

One of the biggest problems that the department faced was to meet the constantly increasing demand for graduate specialists. This was met by constant expansion of all courses, making every effort to get new books and apparatus as it was needed, and getting all the use that we could out of the material on hand until the new supplies were received. To help meet this demand classes were soon introduced on a three weeks' basis. New classes entered the courses every three weeks and pursued the regular twelve weeks course so that we practically had a constant output of graduates. This enabled all books and apparatus to be used by at least two and as high as four different men during the twelve weeks. It was sometimes difficult to fix responsibility for broken or lost property when two men were using the same drawing instruments, typewriters, ammeters and voltmeters, but as the students going through the courses were given a thorough understanding of their responsibility for property this problem soon solved itself. It might be thought that due to the large number of all types of men going through the courses that the material would not last long but this was not true as



Department of Enlisted Specialists, C. A. S.

CLASS ROOM ELECTRICAL COURSE

2246

the men pursuing the courses were doing their very best in all respects and in only very few cases was property lost or destroyed through carelessness.

The following tables showing the numbers of men graduated from this department during the emergency are our record and speak for themselves:

REPORT OF GRADUATES
of
DEPARTMENT OF ENLISTED SPECIALISTS
All Classes—REGULAR AND EMERGENCY

Class	Date of Graduation	Number Graduated	Grade to which Aptd	Warrant
Radio	June 15, 1917	14	Radio Sgt.	Reg.
	Sept. 17, 1917	13	"	Reg.
	Nov. 13, 1917	20	"	Reg.
	Dec. 18, 1917	2	"	Reg.
	Feb. 27, 1918	32	"	Temp.
	June 17, 1918	56	"	Temp.
	July 29, 1918	2	"	Temp.
	Sept. 10, 1918	115	"	Temp.
	Oct. 16, 1918	5	"	Temp.
	Oct. 29, 1918	39	"	Temp.
Artillery	Aug. 3, 1917	13	Mr. Gun.	Reg.
	Aug. 3, 1917	1	"	Temp.
	Nov. 13, 1917	31	"	Temp.
	Feb. 27, 1918	35	"	Temp.
	April 6, 1918	1	"	Temp
	June 18, 1918	46	"	Temp.
	July 17, 1918	21	"	Temp.
	Aug. 13, 1918	21	"	Temp.
	Sept. 4, 1918	24	"	Temp.
	Sept. 10, 1918	21	"	Temp.
	Oct. 12, 1918	13	"	Temp.
	Oct. 24, 1918	10	"	Temp.
	Nov. 2, 1918	21	"	Temp.
	*Nov. 23, 1918	15		
	*Not appointed.			
Electrical	Aug. 3, 1917	42	Elec. Sgt. 2cl	Reg.
	Aug. 3, 1917	17	"	Temp.
	Nov. 13, 1917	68	"	Temp.
	Dec. 10, 1917	6	"	Temp.
	Feb. 27, 1918	84	"	Temp.
	Mar. 30, 1918	16	"	Temp.
	June 17, 1918	107	"	Temp.
	July 10, 1918	19	"	Temp.
	Aug. 1, 1918	7	"	Temp.

Class	Date of Graduation	Number Graduates	Grade to which Aptd.	Warrant
Electrical (con't)	Sept. 11, 1918	93	"	Temp.
	Oct. 15, 1918	30	"	Temp.
	Oct. 28, 1918	25	"	Temp.
	*Nov. 8, 1918	18		
	*Not appointed.			
Clerical	Aug. 3, 1917	21	Sgt-Major Jr.Gr.	Reg.
	Aug. 3, 1917	4	"	Temp.
	Nov. 13, 1917	52	"	Temp.
	Feb. 27, 1918	58	"	Temp.
	June 20, 1918	79	"	Temp.
	Sept. 11, 1918	105	"	Temp.
	Oct. 5, 1918	28	"	Temp.
	Oct. 26, 1918	60	"	Temp.
	*Nov. 16, 1918	53		
	*Not appointed.			

Department of Enlisted Specialists, C. A. S. 2247

TRACTORS DRIVEN BY MOTOR TRANSPORTATION STUDENTS

Department of Enlisted Specialists, C.A.S. RADIO CLASSROOM 2248

Motor Transportation Course

Organization	Graduates	Failed	Relieved or Transferred
45th Art.	59	26	
46th Art.			86
47th Art.	185	51	11
48th Art.	207	40	
49th Art.	194	47	
50th Art.	181	55	2
58th Art.	54	6	
61st Art.	245	47	168
62d Art.	17		
63d Art.	46	4	
64th Art.	60	2	69
66th Art.	102	15	84
74th Art.			14
76th Art.	2		
4th A. A.	60	11	
4th T. M.	37	3	
*17th C.B.	131	7	1
Miscell. or C. D.	1077	239	34
Total	2658	553	469

*Candidates for Training Camp.

No. of grad. during war	Artillery	Clerical	Electrical	Motor Tr.	Radio	Grand Total
Regular	13	21	42		49	
Temporary	260	439	490	2658	249	
Total grad. during war	273	460	532	2658	298	4221
Total grad. previous to war	129	35	389		190	743
				Final total		4964

The largest difficulty met by this department during the emergency was the housing and messing of the great number of candidates who came to Fort Monroe for the various courses and the greatest compliment that can be paid to the highly efficient manner in which this task was handled is to say that no matter how large the number of men they were always well cared for without interfering in any case with their mental training. The same officers who handled the above situation used every effort to drill the men between school hours. They turned them out well disciplined soldiers which is just as essential in the making of a good non-commissioned staff officer as the mental training.

Department of Enlisted Specialists, C.A.S.

MOTOR TRANSPORT PARK

2249

In June, 1918, the first lot of new buildings for the department were ready for use. The Artillery course took over the entire building formerly occupied by both the Artillery and Clerical courses and the Clerical course moved into one of the new buildings. The Radio course was centered in a new building and the Electrical course was given a new building entirely devoted to Fire Control. The Motor Transportation buildings were completed about this date and the whole department with the exception of the Artillery course was grouped closely around the original school building.

USE OF SEXTANTS 2251

When the armistice was signed the department was in the midst of its largest expansion. Thirteen buildings were being built on the new fill between the Chesapeake & Ohio tracks and the Newport News and Hampton Street Railway line. These buildings would have allowed the department to graduate approximately the following number of men every three weeks:

Artillery	50
Clerical	80
Electrical	80
Motor Transportation (each week)	190
Radio	100

Department of Enlisted Specialists C.A.S.

MOTOR TRANSPORT GARAGE

2251

Department of Enlisted Specialists. C A.S

CHASSIS LABORATORY IN ACTION

2252

Only seven buildings were completed when the armistice was signed but these and the material procured for the larger classes equiped the Department of Enlisted Specialists to do its share in building up the Coast Artillery for the new Army no matter what the size or tasks assigned that Corps.

The largest expansion in this department was the Motor Transportation course added in order to meet the demands of the Coast Artillery Corps for men qualified to handle its motors and tractors. On the twentieth day of February, 1918, nine officers were ordered to report to the Coast Artillery School to pursue the Motor Transportation Course. At that time this course existed only on their orders. A few trucks and passenger cars were hastily assembled, and with the assistance of electrician sergeants, the instruction began.

Department of Enlisted Specialists, C.A.S.

PRACTICE WITH FIELD RADIO SET

2263

A definite procedure was outlined on March the fifteenth, although there was almost an entire lack of equipment and a very small instruction force. On April the first, without any buildings in which to teach, and very few men capable to act as instructors, the first class of this department was admitted.

This class numbered two hundred and eighty-nine men. They pursued the course with no small amount of diligence for the dirth of men to handle our motorized apparatus was keenly felt at that time. These men graduated on the twenty-ninth of April.

The manner in which these men were handled may prove to be a matter of interest to those who have observed their splendid work as instructors and convoy men. Their lecture-hall was the Y. M. C. A. building which was utilized at times convenient to that organization. Their laboratories for the study of the apparatus at close range consisted of a large tent erected in the rear of the power plant, under which was crowded a few pieces of the types they were to handle. Their examinations were given in their mess halls, the only buildings available with sufficient capacity.

On May the sixth the present lecture-hall was completed, and on that day a class of two hundred and fifty men were admitted. Every second week thereafter a class of two hundred and fifty men were admitted, giving a flat increase of 100% for the second class. Shortly after we increased our monthly output from five hundred men to six hundred and four men. This was wholly in accordance with the policy of the department to handle every possible man we could take in. About the middle of November the work shifted from a two week interval to a one week interval. This gave us more flexibility and enabled us to increase our monthly output to eight hundred and sixteen.

The only prerequisite for a man entering the Motor Transportation course was a grammar school education. Experience was desired but not necessary. The men on entering were separated into three sections; the men with the most experience in the first, the men with a little experience in the second, and the men with no experience in the third. It was a matter of gratification for us to compare the final standing of these sections. They are consistently even and often the men with the least experience are a few points in the lead.

The course itself had two general divisions, each part covering two weeks. The first two weeks consisted of academic work in the lecture-hall and the laboratories. In the lecture-hall the topic of the lecture was covered in the simplest, most concise manner, every effort being made to bring the more difficult points down to the plane of the student's comprehension. The lectures were invariably accompanied by blackboard illustrations or lantern slide projections pertaining to the subject under discussion. A motion-picture machine was installed in the Assembly hall of the Department of Enlisted Specialists. This hall was of ample size to accommodate the largest sections and proved an ideal place for carrying on the instruction with the aid of motion pictures and carefully selected lantern slides. In cases where it was compatible, parts of the mechanism or other devices under discussion were used for purposes of illustration. In a general way every attempt was made to present the topic in such manner as would enable the student to visualize as nearly as possible the subject taught. It was thus possible to more clearly present the subject under discussion and to increase the student's retentive powers, in addition to increasing his interest and making the subject taught more attractive. At the completion of the lecture the students were given an opportunity to ask questions that may have occurred to them. A period in the laboratories followed the lecture and during this period the students had the lecture driven home to them by actually touching and seeing the apparatus. The instructors in the laboratories were expert men on the parts they instructed upon. At the end of the first two weeks the students were grounded in the fundamentals of construction and operation of the motorized apparatus used in the service, and were ready for the practical work on the road.

During the second two weeks the men were taught to handle tractors, trucks, passenger cars, and motorcycles. This instruction was intensified and the similarity of control of all these pieces enabled the student to gain sufficient experience to give him the necessary confidence to drive and intelligently care for any apparatus to which he might be assigned. The work in this division included a number of night runs. The purpose of these runs was to familiarize the student with the difficulties of night driving and make him able to cope with night conditions. As these runs were made without any lights whatever they tended to increase his alterness and teach him the necessity of being able to drive mechanically, keeping his attention on the road ahead at all times.

When the armistice was signed this course was just completing a textbook on Motor Transportation for Heavy (Coast) Artillery which has since been printed. This book

Department of Enlisted Specialists, C.A.S.

GAS-MOTOR LABORATORY 2254

CLASSROOM---ELECTRICAL COURSE 2255

in all respects would have met the big need for such an article throughout the emergency and now that the intensive training is over it will probably be in great demand whereever any courses on Motor Transportation are conducted.

A summary of the General Regulations in effect in this department during the emergency is as follows:

1. The hours observed by all men on duty in the Enlisted Specialists Department are as follows: Daily except Saturday afternoon, Sundays, and holidays.

8:00 A.M. to 11:45 A.M.
1:00 P.M. to 4:30 P.M.

All students except those in the searchlight section of the Electrical class are required to be present in the classrooms or study-rooms from 7:00 P.M. to 9:00 P.M. daily except Saturdays, Sundays, and holidays. For the searchlight section of the Electrical class, night practical operation periods are provided.

2. The necessary uniform clothing and other equipment will be furnished to the students as soon as practicable after they report for duty and thereafter all men will be required to wear the prescribed uniform as laid down in the School Standing Orders.

3. Students will make themselves familiar with the Standing Orders and Regulations when they are admitted and their actions will conform to these orders as befitting a good soldier.

4. An inspection was held each Saturday at 10:30 A.M., at which time the general appearance of the men with respect to cleanliness and neatness of person and uniform was carefully scrutinized. The condition of the classrooms, laboratories, etc., and the equipment pertaining thereto was also inspected at this time. It was, of course, necessary that all men meet the required standards at these weekly inspections.

A general outline of the courses of study pursued by the emergency classes follows:

OUTLINE OF COURSES

MASTER GUNNER
(Artillery Course)

1. *Duties:* While in this country the master gunner was assigned to the artillery engineer at the various coast defenses.

His duties there consisted of computation of firing data for seacoast guns; triangulation work; map making; making working drawings of broken ordnance parts, etc. Overseas there were four master gunners assigned to each regiment of heavy artillery. Their work consisted of assisting the orientation officer in making field surveys, precisely locating the positions of heavy batteries and their observing stations, finding exact ranges to assigned targets, making working drawings of broken parts which must be replaced by repair shops in the rear; panoramic sketching, laying out spurs and sidings for railroad batteries.

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5-TON ARTILLERY TRACTOR---MODEL 1917 2256

2. *Requisites:* The applicant had to have a thorough grounding in mathematics, including some trigonometry. Six months of mechanical drawing or the equivalent of practical drafting. Surveying was not essential, but was of value to the student, and applicants were required to state in their applications knowledge and experience in this line.

3. *Instruction:* A thorough review of mathematics through trigonometry; surveying, including making of topographical maps; drawing, including working drawings, topographical drawing, panoramic sketching; photography, precise triangulation; and ballistics and gunnery.

4. *Remarks:* (a) The weapon of the master gunner is the Colt .45 pistol. He was instructed in its use and was given

an opportunity of using it on the range.

(b) Practically all graduates of this course were mentally fitted for the Candidates' Course.

(c) Civil engineers by profession found this grade an opportunity to follow their profession during the war.

Hours per week.

Subjects	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week	9th Week	10th Week	11th Week	12th Week	Total hours
Algebra	4½	4½											9
Plane Geometry			4½	4½									9
Solid Geometry													
Slide Rule and Logarithms					4½	4½							9
Plane Trigonometry									4½	4½	4½		13½
Camera at Target Practice												4½	4½
Surveying	18	18	18	18	18	18							108
Drawing	18	18	18	18	18	18			18	18	18	18	180
Ballistics and Gunnery											18	18	36
Seacoast Engineering									18	18			36
Field Survey							40½	40½					81
Total hours	40½	40½	40½	40½	40½	40½	40½	40½	40½	40½	40½	40½	486

Text Books

Algebra: Wentworth.
Plane Geometry: Wentworth.
Solid Geometry: Wentworth.
Slide Rule and Logarithms: Wentworth.
Camera at Target Practice: Steger.
Surveying: Tracy.
Drawing: French
Ballistics and Gunnery: *Gunnery for Heavy Artillery*, Wildrick.
Seacoast Engineering: Artillery Notes No. 11.

SERGEANT-MAJOR

(Clerical Course)

1. *Duties:* At home the sergeant-major is secretary to the commanding officer of the Coast Defense and works directly under the adjutant. He is in charge of all the "paper work" of his organization. In France, eight are assigned to every regiment of heavy artillery, two are senior grade and six are junior grade. They are assigned to regimental and battalion headquarters and handle all paper work that goes through those headquarters.

2. *Requisites:* Stenographers with office experience: typists, secretaries of business houses and men of office experience,

are eligible. Stenography is not essential, but of value. Clerical experience is essential.

3. *Instruction:* Spelling, typewriting, Army paper work and official communications, *Army Regulations, Manual of Courts-Martial,* blank forms and service filing systems.

4. *Remarks:* (a) Students are graduated as sergeant-major, junior grade, and promotion to the grade of sergeant-major, senior grade, is by selection, the best men going up as vacancies occur.

(b) The sergeant-major is armed with the Colt .45 caliber pistol.

(c) A sergeant-major must be neat and soldierly and set an example to the other non-commissioned officers of his organization.

(d) A sergeant-major is the senior non-commissioned staff man and as such is first sergeant of the non-commissioned staff.

Hours per week.

Subjects	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week	9th Week	10th Week	11th Week	12th Week	Total hours
Spelling	3	3	3	3	3	3	3	3	3	3	3	3	36
Stenography	9	9	9	9	9	9	9	9	9	9	9	6	105
Manual of the Saber												6	6
Typewriting	10½	10½	10½	10½	10½	10½	10½	10½	10½	10½	10½	7½	123
Official Communications	9	9											18
Filing			9	9	9								27
Official Papers						9	9	9	9	9	9	9	63
*Manual Interior Guard Duty	9	4½											13½
*Infantry Drill Regulations		4½	4½										9
Manual Courts-Martial			4½	1½									6
Coast Artillery Drill Regulations				7½	3								10½
Coast Artillery Instruction Orders					3								3
Field Service Regulations					3	1½							4½
Compilation of Orders						7½	9	9	9	9	9	9	61½
Total hours	40½	40½	40½	40½	40½	40½	40½	40½	40½	40½	40½	40½	486

*Includes drill

Text Books

Spelling: *Words*, Gregg Publishing Co.

Stenography: Elementary Class, Manual of Gregg Shorthand. Advanced Class, all systems of shorthand.

Manual of the Saber: Manual of Interior Guard Duty.

Typwriting: *Rational Typewriting*, Gregg Publishing Co.

Official Communications and Official Papers: *Army Paperwork*, Moss.

Filing: War Department Correspondence File.

Manuals of Infantry Drill, Courts-Martial, and Field Service Regulations, Coast Artillery Drill Regulations, General Orders, Circulars, Bulletins of War Department, etc.

Electrician Sergeant

(Electrical Course)

1. *Duties:* Electrician sergeants are charged with the care, operation and repair of electrical installations of Coast Artillery Posts. In France, the work in the main will consist of installing and maintaining electrical communication systems of the regiments to which they are assigned and such other electrical work as may be required within those regiments.

2. *Requisites:* Familiarity with electricity and electrical apparatus, either through laboratory or practical experience; a knowledge of mathematics to include elementary algebra in order to calculate simple electrical problems. He should be able to solve easily problems with one unknown quantity. The first three weeks of the course are a rapid review. It is therefore necessary that the applicant know something of the elementary theory of direct currents before coming to the school; otherwise he will not be able to keep up.

3. *Instruction:* Motors and generators; laboratory practice, D.C. and A.C. apparatus; fire control apparatus; storage batteries; cable tests and repairs; internal combustion engines; searchlights; machine shop practice; steam engines and boilers; wiring.

4. *Remarks:* Students are graduated as electrician sergeants, second class, and may be promoted by seniority to the grade of electrician sergeant, first class, assistant engineer, engineer, and by selection to the grade of master electrician.

Elementary Electricity

PERIOD: First three weeks.

Subjects Covered: Magnetism; Ohm's law; divided circuits; measurement of resistance; power; dynamos and motors; ammeters, voltmeters and wattmeters; transformers; alternators; capacity; inductance; elementary A. C.

Text Books: Elements of Electricity, by Timbie; advertising matter by various manufacturing companies.

Fire Control and Fault Location

PERIOD: Fourth to sixth week, inclusive.

Subjects Covered: Sound; telephone transmitters; receivers; induction coils; batteries; magnetos; polarized bells; local battery telephones; extension bells; condensers; retardation coils; common battery telephones; protective devices; repeating coils; storage batteries; central energy boards; special telephone apparatus as used in Coast Artillery; monocord boards and field telephones as used on the Western front; wheatstone bridges; slide wire bridges; bridgemegger; fault finder; dial decade sets; ohmmeters. Fault location, capacity and insulation tests of cables with reflecting galvanometer.

Text Books: Principles of the Telephone, by Jansky; *Signal Corps Manual No.* 8; *Signal Corps Engineering Pamphlet No. 3;* advertising matter.

Internal Combustion Engines and Searchlights

PERIOD: Seventh to ninth week, inclusive.

Subjects Covered: Elementary mechanics; machine elements; heat engines; fuels; four and two stroke cycle gas engines; cooling; governing; ignition systems; carburetors; lubrication; testing; carbons and arc characteristics; lamp mechanism; controllers; mirrors; G.E. searchlight; Sperry searchlight.

Text Books: Gas Engines and Gas Power, by Hirshfeld and Ulbricht; instruction books on 25 K. W. set; cagalogs of various manufacturers. Mimeographed reading matter; instruction books on the G. E. and Sperry searchlights.

Cable Splicing

PERIOD: Tenth week.

Subjects Covered: Splicing various kinds of wire and cable—both power and telephone; lead joints; soldering.

Text Books: N. E. Code; S. C. Manual No. 8; *Joint Wiping and Lead Work,* By W. Hutton.

PERIOD: Eleventh week.

Subjects Covered: Bench and vise work; babbitting and floor work; piping; conduit work; lay-out; erecting; fastenings;

blacksmithing and pipe bending; maintenance; machine tool operation.

Machine Shop Practice

Text Books: I. L. T., Vols. 1B and 2B; machinery catalogues; *American Machinists' Handbook*; *Textbook of Advanced Machine Work*, by R. H. Smith.

Steam

PERIOD: Twelfth week.

Subjects Covered: Boilers and accessories; fuel; combustion; firing; chimneys and draft; engines and accessories; lubricants; lubrication; tests.

Text Books: *Steam Boilers*, by Shealy; *Steam Power*, by Hirshfeld and Ulbricht; *Steam*, by B. and W. Co.; *Helios*, by Heine Safety Boiler Company.

FIELD RADIO 2257

RADIO SERGEANT

(Radio Course)

1. *Duties:* The radio sergeant handles the radio apparatus of the Heavy Artillery, which forms the liaison between aircraft and artillery, and communication with other units at a distance.

2. *Requisites:* The applicant should be proficient in mathematics to include elementary algebra and should be able to send and receive at least ten words per minute in the Continental Code. Should have three years' high school education or equivalent.

3. *Instruction:* Buzzer operating; keywork on code; the electrical circuit and electrical units; storage batteries, radio apparatus; radio sets; radio laws; other forms of signalling and practical field work.

Hours per week.

Subjects	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week	9th Week	10th Week	11th Week	12th Week	Total hours
1. Military Subjects	27¼	27¼	27¼	25¾	25¾	25¾	24¼	24¼	24¼	24¼	24¼	35¼	315½
2. Buzzer Practice	21½	21½	21½	21½	21½	21½	21½	21½	21½	14	14	11½	233
3. Laboratory	7½	7½	7½	7½	7½	7½	7½	7½	7½				67½
4. Class Work	18½	18½	18½	18½	18½	18½	18½	18½	18½	2¼	2¼	2¼	173¼
5. Field Practice										36¾	36¾	41¼	114¾
Total hours	47½	47½	47½	47½	47½	47½	47½	47½	47½	53	53	55	588½

1. Military Subjects include: Military lectures; medical lectures; infantry drill; gas drill; calisthenics; mess; (Recreation).

2. Buzzer Practice Includes: Without jambing; with jambing; buzzer and blinker shoots; semaphore and wig wag; examination.

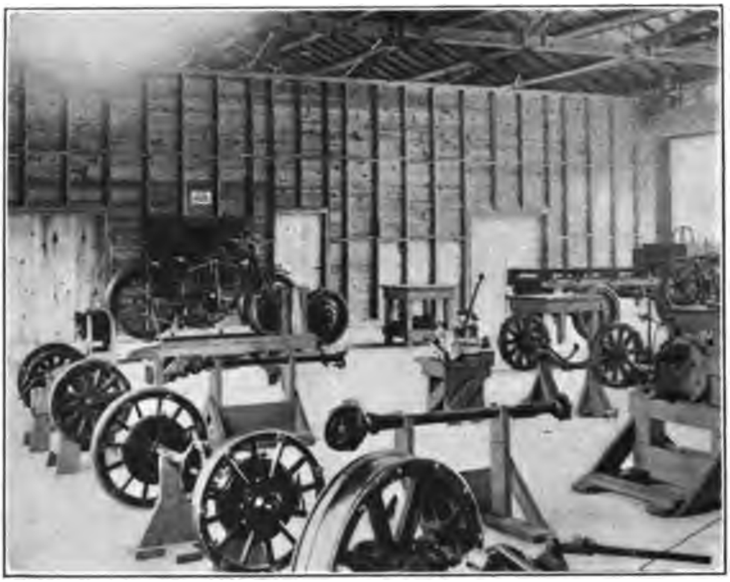
3. Laboratory Work includes: D. C. electricity and magnetism; resistance; power measurements; batteries; D. C. motors and generators; A. C. electricity and A. C. machinery; elementary radio circuits; wave meters; resonance and tuning transmission sets; receiver sets and circuits; detectors and vacuum bulbs; continuous wave sets and radio telephone; antenna, grounds, care of sets; rules and regulations.

4. Class Work includes: Study of text books and reading assignments; preparation of note books and examination.

5. Field Practice includes: Testing of storage batteries; lectures; operation of sets in field; drill in setting up antenna units; lectures on artillery panels; practice with artillery panels and artillery shoots; notes and diagrams.

Text Books used: Elements of Electricity, by Timbie; *Elementary Principles of Wireless Telegraphy*, part 1 and part 2, by Bangay; *Radio Telegraphy and Telephony*, by Robinson; *Radio Telegraphy*, Signal Corps pamphlet.

Reference Books: Wireless Telegraphy, by Stanley; *Principles of Wireless Telegraphy*, by Pierce; *Practical Wireless Telegraphy*, by Bucher; *Vacuum Tubes in Wireless Communication*, by Bucher; *Alternating Currents Simplified*, by Burns; *Practical Uses of the Wavemeter in Wireless Telegraphy*, by Maubargne.



Department of Enlisted Specialists, C.A.S.

CHASSIS LABORATORY 2258

In order to co-ordinate the work of the men who successfully pursue the Radio Course and the other departments of the Artillery and the Signal Corps, actual practice is given under simulated warfare conditions. This includes panel signalling and radio communications with aeroplanes, establishing communications between observation stations and batteries, establishing communications between batteries and battalion, regimental and brigade headquarters, etc.

MOTOR TRANSPORTATION COURSE

1. *Duties:* The driving of trucks, tractors, passenger cars, and motor cycles for the Heavy (Coast) Artillery regiments going to France.

2. *Requisites:* A grammar school education. It is *preferred* that the applicant have had some experience driving motor vehicles. The course should appeal especially to men who have had garage or road experience with automobiles.

3. *Instruction:* The Motor Transportation Course covers a period of four weeks. The first two weeks include classroom and laboratory work, which cover the theory and operation of internal combustion engines, fuels, cooling systems, lubrication, electrical appliances, and the study of the parts of the mechanism, trouble hunting and repairs. The last two weeks are devoted to practical work in the field under conditions similar to those found in France, including the driving of trucks, caterpillar tractors, etc.; driving at night without lights; convoy signals, road discipline, and roadside care; upkeep and adjustment of motor vehicles.

Detailed Outline of Course

FIRST TWO WEEKS:

(1) *Class Room Lecture Work:* 14 hours first week; 12 hours second week.

The theory and operation of four cycle gas engines, cooling systems, fuel feeds, carburetion, governors, elements of ignition as applied to motor vehicles; ignition as applied to motor vehicles; tires; lubrication; troubles; power transmission, clutches, transmissions, universals, running gear, etc. 26 hours.

(2) *Laboratory Work:* 26 hours first week; 31½ hours second week.

Supplements and expands on matter covered in lectures by practical demonstration and work with the apparatus. 57½ hours.

(a) *Ignition Laboratory:* Current electricity; self-induction; mutual induction; construction and wiring of battery ignition system; study of ignition systems in Government use; ignition troubles. 21¼ hours.

(b) *Motor Laboratory:* Gas engines; nomenclature; taking down and assembling of various gas engines; valve timing; valve grinding; valve troubles; cooling systems and troubles to be encountered; fuel feed systems; lubrication; adjustment of various types of carburetors. 21¼ hours.

(c) *Chasis Laboratory:* Power transmission and nomenclature; universal joints; clutch assembly and adjustment; transmissions of various types of apparatus; differentials; brakes and adjustments. Springs, wheels, axles, and steering devices. 15 hours.

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SECOND TWO WEEKS:

(3) *Practical Road Work:* 40 hours third week; 40 hours fourth week.

This work is taken up after the student has received a thorough grounding in the theory of motor vehicles. Care and operation of caterpillar tractors; care and adjustment of ammunition trucks; the operation of and convoy practice with ammunition trucks; driving of passenger cars and motor cycles. 80 hours.

(a) *Care and Operation of Caterpillar Tractors:* Nomenclature; lubrication; operation of caterpillar tractors with and without load. Special emphasis is placed on lubrication and adjustments. 21 hours.

(b) *Care and Adjustment of Ammunition Trucks:* This work involves a very thorough and careful study of all essential adjustments and lubrication encountered on standard trucks. Points covered are ignition systems; valve clearance and valve timing; wheel alignment and lubrication; inspection of axles, steering gears and propeller shafts; lubrication and care of clutches and transmissions; lubrication and care of springs; fuel feed and carburetor troubles; and care of cooling systems. 17½ hours.

(c) *Convoy Practice With Ammunition Trucks:* The student is taught to start, stop, shift gears and steer for three half days. Extended convoy work then begins and continues for the remainder of the work. Student is thoroughly grounded in convoy signals; night practice; operation, loaded and light. Every effort is made to duplicate actual field conditions.

(d) *Motor Cycle and Passenger Car Work:* Student is also given 3½ hours motor cycle and 3½ hours passenger car work.

Saturday morning a thorough inspection of all apparatus is carried out. (c) and (d) 41½ hours.

Text Books used: Automobile Encyclopedia, by Dyke; *Modern Gasoline Automobile,* by Pagé; *The Gasoline Automobile* by Hobbs and Elliot; *Questions and Answers,* by Audel. Mimeograph sheets compiled by instructors at school; students are furnished with master note sheets to be filled out during lectures and laboratory work.

THE COAST ARTILLERY TRAINING CENTER AND CAMP EUSTIS

By Lieutenant Colonel Fred M. Green, C. A.

Prior to the outbreak of war, the Commanding Officer of the Coast Defenses of Chesapeake Bay was ex-officio Commandant of the Coast Artillery School. The conditions at this time were such that a single officer could efficiently supervise the activities of both. With our entrance into war, the situation was; considerably altered: where there had been but one garrisoned post and a sub post, the Coast Defenses were increased to four garrisoned forts, two of which had yet to emplace their armament and prepare their shelter and defenses. New regular companies were created with the expansion of the army. Recruits swarmed in, were hastily drilled in civilian clothing, and were assigned to units. Newly organized companies of National Guard arrived, and had to be assigned to armament and trained. A submarine net was fabricated and installed, and precautions against raids by submersibles had to be taken.

Meanwhile the officers' division of the Artillery School as it had previously existed was closed, owing to the need for the services of the officers on duty there. As it became evident that thousands of new officers must be trained for the armies to be raised, preparations had to be made for the selection and training of the Coast Artillery quota. Since the Artillery School buildings were standing idle, and since Fort Monroe possessed a library and much equipment adaptable for work along these lines, this post was naturally selected as the site for the location of this new school. The expansion of a plant designed for classes of forty men into one capable of handling classes of three thousand has already been described. The mass of work required to supply, mess, equip and train these men necessitated the organization of a new and elaborate staff, supervised by a Training Camp Commander.

Thus it is seen that both the Coast Defense and the Training Camp became independent agencies, working along new and totally different lines, and each requiring the entire attention of a single responsible head. That two uncoordinated and independent activities should exist upon the same reservation was evidently undesirable. Yet a third unit actually existed in the Enlisted Specialists School, now operating on a war basis. While administratively it was under the Commandant of the School, yet its work was distinctly different from that of the Training Camp for reserve officers.

Meanwhile, the French Artillery officers detailed on duty with the Training Camp were urging the establishment of a land firing-range. Owing to the nonexistence of heavy mobile artillery in this country, our seacoast guns had necessarily been our main reliance for training purposes, tho as nearly as possible the methods of the Western Front were employed in the direction of their fire. To the battery commander and to the few intimately associated with him in his computations, the simulation was fairly complete, but to the mass of candidates the illusion was far from convincing. Confusion between seacoast and mobile methods and equipment was heightened by this expedient, and since it was found that some heavy mobile guns were shortly to be available for training purposes, the selection of a site for a land range was decided upon.

Obviously, this range must be located upon ground whose commercial value was small. The country around Fort Monroe was investigated with a view to choosing a site which would meet the many and somewhat conflicting requirements. This resulted in the determination that Mulberry Island in the James River offered a suitable target-ground. Medium and short ranges could be had from the vicinity of the present site of Camp Eustis, and the long ranges required for railway armament could be attained by firing over the river-course from the present "upper firing point." The original conception of Camp Eustis was that it was to be a firing range only.

In April, 1918, or about a year after our entrance into the war, the erection of cantonment buildings was begun. The difficulties of the undertaking can be realized only by those who have seen the roads as they were in the early days. Such roads and trails as existed were rapidly churned into a sort of slimy foam by the passage of heavy loads over them, and seemingly bottomless mudholes were the rule rather than the exception. The trees felled in clearing the camp-site were used to corduroy the roads. Railroad approaches had been completed about this time, and construction material began to pour in.

Even before the barracks had been erected, Mulberry Island had been occupied by troops, a trench mortar battalion being the first organization to camp there. Its two batteries were camped on Mulberry where the targets are now. The function of these batteries was to furnish Military Police for the Constructing Quartermaster and to dig trenches for targets subject to firings. The tale of their adventures is a long one. The supply of drinking water was very limited, even for so small a unit, and an attempt to dig an ice-box resulted in the uncovering of human remains, extinct slaves

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and former inhabitants of the slave colony at Jail Point, the extremity of Mulberry Island. Their ruined huts stand today as grim reminders of the days of slavery.

Eventually, a sufficient supply of water was provided from artesian wells, the camp now being absolutely independent of any outside source of water; and the shipment of troops to Camp Eustis in quantity was possible.

Regimental Headquarters and two Battalions of the 61st Artillery were the first troops to actually occupy the present site of Camp Eustis. They lived in the newly constructed cantonments.

TRACTOR DRAWING 6-INCH GUN 2281

Meanwhile, it had been found that the original system of organizing and equipping regiments of heavy artillery in the Coast Defenses was not entirely successful. For example, a regiment slated for organization upon the Pacific Coast might have batteries from San Diego to Puget Sound. Supplies for each battery had to be shipped to these several coast defenses, which involved considerable delay, and when they were eventually received the organizations would re-ship them to the point of embarkation or other place of assembly. It was further apparent that owing to the enormous demand for matériel and supplies, and the unsatisfactory status of rail transportation, the simultaneous isolated efforts of coast dedefense supply officers led only to increased confusion and delay.

In view of this, the decision was made that not only should troops be trained in artillery firing at Camp Eustis, but also they should complete their organization and supply at that place. Hoboken ceased to be the port of embarkation for heavy artillery troops, and Newport News became its more convenient successor.

Altogether, about 20,000 men passed through Camp Eustis. The 37th and 38th Brigades, the 4th Anti-Aircraft Battalion, 13th, 14th, 15th, and 16th Companies.Anti-Aircraft, the 56th and 57th Ammunition Trains, and the 4th Trench Motor Battalion were assembled and trained there. The amount of firing done was less than had been anticipated, due partly to the amount of time required in supplying the troops and completing their organization, and partly because of defective ammunition, (the fuzes furnished having proved defective and their replacement proving a slow matter). Experience with aerial observation could be had, however, through the adjacent Balloon School and the proximity of Langley Field. The necessary struggles to get those systems linked up probably proved of greater ultimate value to those concerned than would have been the case had a smooth-running machine already been in existence.

The nature of the instruction given at Camp Eustis was very varied. Not only was there straight artillery firing, with all the mechanical maneuvers, layout of battery positions, orientation work and computation of firing data incidental thereto, but in addition there was infantry drill, signalling, physical drill, small-arms practice, machine gun instruction, and drill and instruction in gas defense. To give instruction in all of these subjects in the Coast Defenses was evidently impossible; for example, few officers were qualified as instructors in gas defense, and even drill masks were few. By successively instructing regiments at Camp Eustis, a great saving of time was made and infinitely better instruction became possible. Similarly, the conduct of small-arms firing in most Coast Defenses leaves much to be desired; there is usually but one range, and that is frequently located with a view to safety rather than accessibility and convenience, but at Camp Eustis the range was conveniently located and firing could be continuous.

In the artillery firing work proper, the battery commander was caused to execute each step required in emplacing and conducting the fire of a battery. Owing to the wooded nature of the firing position, the orientation work had to be carried on with short sights, just as was to be expected in the case of a battery taking position in a wooded sector.

As to the maneuvering of the guns along the road, the actual distances to be covered were short, but no one acquainted with Virginia roads will hesitate to accept the statement that the character of this instruction was "*intensive*"! To Further simulate service conditions as they existed on the Western Front, battery commanders were required to emplace their batteries without being observed by aeroplanes. At least three aerial photographs were taken during each problem of getting a battery into position. If any evidence of the battery's work was seen, the entire problem had to be gone through with again.

Army Balloon School Near Camp Eustis

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Camp Eustis differed in its nature from the Coast Artillery School and from the coast defenses. While more closely linked to the former, its function as an administrative and supply centre gave it an independent character. The separation of the military departments into smaller units had already proved advantageous, and in line with this policy of decentralization these four allied units—Training Camp, the Enlisted Specialists' School, the Coast Defenses and Camp Eustis—together with the Coast Artillery Board, Library, etc., were organized into a self-contained unit in August and September, 1918. This unit was designated as the Coast Artillery Training Center, and consisted of three commands: Camp Eustis, including Mulberry Island and the Firing Range; the Coast Defenses of Chesapeake Bay; and the Coast Artillery School, including what had formerly been the Training Camp, the Enlisted Specialists' School, the Coast Artillery Board, Library, etc. The Coast Artillery Training Center was organized by Brigadier General F. K. Fergusson and commanded by him until about February 1, 1919, when he was relieved by Brigadier William Chamberlaine.

The function of the Coast Artillery Training Center has been mainly to co-ordinate the various activities within the above units, and to preserve liaison between the Office of the Chief of Coast Artillery and the several units enumerated. To some extent it resembles a Coast Artillery District, and in other respects it exercises the functions of a Department. Its service has tended to eliminate the loss of time, misunderstanding and inconvenience of having to refer questions of lesser importance to a distant higher authority.

Between the dates of June 22, 1918, and December 21, 1918, the following organizations passed through Camp Eustis:

Organization and Commander	Arrived	Departed or Demobilized	Strength	
			Officers	Enl. men
61st Artillery, C.A.C. Wm. F. Stewart, Col.	June 22/18	July 10/18 To P. of E.	54	1757
4th Trench Mortar Bn. B. S. Beverly, Capt.	June 30/18	Sept. 25/18 To P. of E.	32	775
4th Anti-Aircraft Bn. C. M. Wood, Major	June 30/18	Sept. 25/18 To P. of E.	21	535
50th Artillery, C.A.C. R. T. Ellis, Col.	July 1/18	Sept. 27/18 P. of E.	53	1921
		Total	160	4988

Organization and Commander	Arrived	Departed or Demobilized	Strength	
			Officers	Enl.men
		Carried for'd.	160	4988
49th Artillery, C.A.C. LeVert Coleman, Col.	July 1/18	Sept. 27/18 P. of E.	54	1796
48th Artillery, C.A.C. C. B. Smith, Col.	July 1/18	Sept. 27/18 P. of E.	55	1823
38th Brigade Hq. (48, 49, 50th Regts) G. E. Johnson, Capt.	Aug. 11/18	Sept. 27/18	4	50
47th Artillery, C.A.C. Jos. S. Hardin, Col.	July 3/18	Oct 8/18 P. of E.	67	1716
46th Artillery, C.A.C. Francis N. Cooke, Col.	July 1/18	Oct. 8/18 P. of E.	64	1636
45 theArtillery, C.A.C. W. F. Hase, Col.	July 3/18	Oct. 12/18 P. of E.	65	1702
37th Brigade Hq. (45, 46, 47th Regts) C. H. McNeil, Brig. Gen.	Sept. 9/18	Oct. 12/18	4	51
13th Anti-Aircraft Bty. J. H. Babbitt, Capt.	July 3/18	Sept. 27/18 P. of E.	3	66
14th Anti-Aircraft Bty. H. F. Grimm, Capt.	July 3/18	Sept 27/18 P. of E.	2	67
15th Anti-Aircraft Bty. H. C. Meredith, Capt.	July 3/18	Sept. 17/18 P. of E.	2	67
16th Anti-Aircraft Bty. D. O. Piper, Capt.	July 3/18	Sept. 27/18 P. of E.	2	65
36th Artillery, C.A.C. Jos. P. Tracy, Col.	Oct. 4/18	Nov. 6/18 P. of E.	56	1932
37th Artillery, C.A.C. H. L. Steele, Col.	Oct. 2/18	Nov. 6/18 P. of E.	45	1819
38th Artillery, C.A.C. James Totten, Col.	Oct. 2/18	Nov. 6/18 P. of E.	53	1802
41st Brigade Hq. (36, 37, 38th Regts) A. H. Sunderland, Brig. Gen.	Sept. 29/18	Nov. 6/18	8	52
		Total Departed	644	19632
56th Ammunition Tn. K. L. Fleming, Major	July 8/18	Dec. 20/18 Demobolized	11	609
57th Ammunition Tn. Frank R. McReynolds, Maj.	July 8/18	Dec. 18/18 Demobilized	11	233
15th Anti-Aircraft Sector, (formerly 8th A–A Bn.) E. L. Ford, Major	Oct. 22/18	Dec. 21/18 Demobolized	14	432
16th Anti-Aircraft Sector (consisting of 21, 22, 23, 24, 25th A-A Batteries) J. B. Holmes, Major.	Nov. 10/18	Dec. 19/18 Demobolized	10	447
		Total	46	1721

Organization and Commander	Arrived	Departed or Demobilized	Strength	
			Officers	Enl.men
		Carried for'd	46	1721
17th Anti-Aircraft Sector Lloyd M. Hanna, 1st Lt.	Nov. 14/18	Dec. 23/18 Demobolized	6	420
30th Artillery, C.A.C. Wm. N. Porter, Col.	Nov 7/18	Dec. 20/18 Demobolized	34	1591
31st Artillery, C.A.C. Meade Wildrick, Col.	Nov. 6/18	Dec. 20/18 Demobolized	34	1734
32nd Artillery, C.A.C. Harry W. Newton, Col., succeeded by B. H. Pendry, Lt-Col.	Nov. 8/18	Dec. 19/18 Demobolized	56	1752
43rd Brigade Hq. 30, 31 and 32 Regts	Nov. 6/18	Dec. 21/18 Demobolized	3	50
27th Artillery, C.A.C. Louis C. Brinton, Jr., Col.	Nov. 3/18	Dec. 20/18 Demobolized	51	1734
33rd Artillery, C.A.C. Stephen H. Mould, Col.	Oct. 30/18	Dec. 21/18 Demobolized	58	1675
34th Artillery, C.A.C. E. E. Farnsworth, Col.	Oct. 19/18	Dec. 19/18 Demobolized	52	1749
42nd Brigade Hq. (27, 33, 34th Regts)	Oct. 30/18	Dec. 21/18 Demobilized	3	51
	Total Departed and Demobolized		987	32109

PROFESSIONAL NOTES

EXTRACTS
from
REPORT OF THE CHIEF OF COAST ARTILLERY TO THE SECRETARY OF WAR, 1918.

Methods of Fire Control and Observation of Fire

The methods of fire control used abroad in the war zone do not differ in principle from those that have long been in use by the Coast Artillery Corps. Acutal experience has demonstrated the importance of all the corrections commonly applied in our service. Practically all modifications have been in the direction of further refinement and of securing additional data for use in computing corrections. The extension of these methods to the control of Field Artillery fire is worthy of note. In a report of an officer of Field Artillery, now commanding a division, he states:

"After a period of nearly six months' observation of the employment of artillery in war of position, I am more than ever impressed with the necessity of the greatest possible accuracy of fire. Every officer in the Field Artillery must be able to compute firing data with great accuracy, to adjust fire on the auxiliary target, to transport fire accurately and to abserve fire with great skill. I am therefore of the opinion that the firing data must include every element affecting the flight of the projectile, including the powder lot, the correction of the moment, the error of the gun, the temperature of the powder, and so fourth. This work must be done with skill, rapidity, and accuracy. It is seldom possible to see the actual target, such as the barrage line, the enemy's trench or even the position of a battery. It is therefore necessary, in practically all cases, to make an adjustment on some point like a church, a cross road, a cemetery, or other conspicuous landmark which has been accurately located on the map. It is therefore necessary, practically always, to prepare the original firing data from the map. With reference to the correction of the moment, I am of the opinion that it is unreliable unless used very shortly after the atmospheric conditions have been obtained. It is therefore necessary, in practically all cases, even after an accurate adjustment has been obtained, to fire trial shots immediately before the delivery of any mission. For example, in an attack it is necessary to allot as much as two hours, with an allowance of from five to ten minutes for each battery, to verify its firing data before the hour for fire for effect arrives. This rule must be followed in all cases. I am even of the opinion that it is better to fire a few shots in the dark and endeavor to note the point of burst from the nearest possible observation point than to attempt to fire for effect without such preliminary trial shots. The point of fall has been seen to vary considerably in two series of shots fired in front of our Infantry one-half hour apart."

The necessity for the observation of fire and the adjustment and maintenance of the center of impact upon the target by means of such observation was recognized early in the war. The development of means to accomplish this came rapidly, and at present, fire without observation may be regarded as the exception. In the war zone practically all targets are stationary. In the coast defense service practically all targets are moving. This adds materially to the difficulty of applying corrections based upon observation. However, any system which does not contemplate such corrections may be regarded as obsolete, and it is believed that the experience of our officers, gained in the field, together with their ingeniuty in overcoming difficulties this nature, will enable a satisfactory solution of the problem to be reached. The subject will be given attention in all coast defenses, and the suggestions which reach this office will be scrutinized with care. The Coast Artillery Board at Fort Monroe, has been directed to study the subject and all schemes which warrant it will be given a practical test as promptly as possible.

DEVELOPMENTS OF THE WAR AS APPLIED TO COAST DEFENSE

In order that the general trend of development in heavy artillery may be studied and applied properly to seacoast defense, it is desireable to state the general features of this development and to suggest the principles which appear to underlie their application.

(a) Gun power.—This has increased both in range and the caliber of the gun. Guns of 24-inch, ranging to 40 miles, may be realized while longer ranges for special types are possible if desired.

(b) Mobility.—Guns of the largest caliber are transported on their firing carriages by rail. The calibers of tractor drawn matériel have increased materially, and it is unlikely that the limits have yet been reached.

(c) Aeroplane bombardment.—Although this is not a strictly artillery development it should be considered in connection with the effects of artillery fire inasmuch as the aeroplane may be regarded as taking up these effects at the longer ranges and projecting them far back into enemy territory.

Seacoast defense may be considered as divided into two parts: First, harbor defense, which has for its object the protection of important ports in order that they may serve as bases of operation for the Navy; second, coast defense proper, in which the coast line is the frontier and fortified harbors serve as supporting points.

The function of fortifications for harbor defense is twofold: (a) The security of the port, including the protection from bombardment of all its utilities, especially those of vital importance to the fleet; (b) The maintenance of a clear area in front of the harbor entrance which will afford our own fleet the opportunity of egress from the harbor without coming under the fire of the hostile fleet.

The means of defense of the coast line as a whole are the entire mobile forces of the Nation. Upon these forces rests the responsibility of protecting the fortified naval bases from enemy raids, which may be attempted by landing in the vicinity. The dispositions should be such as to prevent such landings. It will, however, be impossible to insure that no landing be made along the entire coast line. The object sought in locating the mobile forces to meet such operations should be to place them at strategic points which will enable them to move to the sea frontier in time to attack the enemy before his landing is completed.

The rôle of heavy artillery in these subdivisions of coast defense is not entirely the same in both cases. For harbor defense the guns must be on the spot at all times prepared to forbid the presence of hostile vessels in certain sea areas. For the general defense of the coast line the mobile troops assigned to that duty should be accompanied by heavy artillery prepared to attack either land formations, transports or the armed naval vessels which will be supporting the troops engaged in the landing operations.

It remains to consider in what respects the development of the war has changed previous ideas on this subject. In the case of harbor defenses the existing armament lacks in power when judged by the latest standards. It is, however, an important inner defense system and will accomplish the purposes of such a system most effectually. In order to provide for the unhampered movements of our own fleet in leaving important harbors it will undoubtedly be necessary to supplement the existing defenses with the highest power largest caliber guns, placed as far to the front as possible. In order to accomplish this it will be necessary in many cases to occupy islands. Under these circumstances the increased mobility of high-powered guns is of no value, and recourse will consequently be had to fixed emplacements. Where headlands connected with the main line are suitable for emplacing this class of armament the use of railway mounts may be justified. This might enable such guns to be withdrawn for service with the mobile forces or to reinforce points under actual attack.

As regards the general defense of the coast line the absolute impossibility of utilizing mobile artillery, either tractor or railroad drawn, with the view of preventing a naval raid upon bathing beaches or summer resorts, must be recognized. The function of such artillery is to accompany and support the armed mobile forces which must be advanced to meet the hostile enterprise as near the beach as possible.

The foregoing is intended as a brief mention only of the salient points of this subject in order that in the study of specific projects, which will be continually arising in the future, the general principles may be understood and correctly applied in all cases.

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Railway Artillery Reserve, American E. F.

There appears below, a copy of paragraphs II and III, General Orders No. 51, Headquarters, Railway Artillery Reserve, American E. F.

This order shows in paragraph II, the units which, on November 11, 1918, the date on which the armistice became effective, constituted the Railway Artillery Reserve, American E. F.; and in paragraph III, the dates on which, and the localities in which, the various units were in action against the enemy, and the Army with which each was serving at the time.

It will be seen from this order that the units of the Railway Artillery Reserve, American E. F., were in action during various periods with the II, IV, VII, VIII, and X French Armies in various localities from the vicinity of SOISSONS (Aisne), to the vicinity of BELFORT (Belfort), as well as with the 1st and 2nd Armies, American E. F., in the ST. MIHIEL and ARGONNE-MEUSE operations.

The Railway Artillery Reserve, American E. F., was composed of troops of the Coast Artillery Corps and certain staff corps troops attached. Later a U. S. Naval detachment of about 450 men was incorporated in the command. The nucleus of the organization consisted of the First Expeditionary Brigade, Coast Artillery Troops, which was organized at Fort Adams, Rhode Island, in July-August, 1917, under command of Brigadier General George T. Bartlett, U. S. A., and consisting of the 6th, 7th, and 8th Provisional Regiments, Coast Artillery Corps. The Brigade sailed for France in August, 1917, and from it was developed the Railway Artillery Reserve, American E. F., as shown in paragraph II of the order. After its arrival in France, the designation of the First Expeditionary Brigade, Coast Artillery Troops, was changed to "First Separate Brigade, C.A.C." then to "30th Artillery Brigade (C.A.C. Railway)," then to "Railway Artillery Reserve, 1st Army, American E.F." and finally to "Railway Artillery Reserve, American E.F." It was commanded by Brigadier General Frank W. Coe, U.S.A., (now Major General and Chief of Coast Artillery) until the middle of 1918. From that time until its demobilization in December, 1918, it was commanded by Brigadier General William Chamberlaine, U.S.A.

The word "Reserve" in connection with Railway Artillery was really a misnomer, and was an adaption from the French "Reserve Generale d'Artillerie." The Railway Artillery was not a reserve in the English sense of the word, but was a reservoir from which was drawn Railway Artillery units as needed on the various fronts. It was a mass of Railway Artillery held at the disposition of the Commander in Chief, ready at all times for temporary assignment according to the tactical needs of the situation to any of the French or American Armies. As soon as a mission was completed, the units assigned to it were returned to the base to be refitted, reorganized, re-equipped and made ready for immediate further service. The Railway Artillery was not permanently assigned to any Army, Corps, or Division.

HEADQUARTERS RAILWAY ARTILLERY RESERVE,
AMERICAN EXPEDITIONARY FORCES, FRANCE
20 December 1918.

GENERAL ORDERS
No. 51.

II. At the signing of the Armistice, 11 November 1918, the Railway Artillery Reserve, American Expeditionary Forces, was composed of the following organizations:

Railway Artillery Reserve, A.E.F., Headquarters Staff,
Railway Artillery Supply Depot, A.E.F.
Military Police Detachment,
Motor Transport Service Detachment,
Railway Artillery Repair Shop,
1st Provisional High Burst Ranging Section, R.A.R.
1st Railway Artillery Operation Battalion, A.S.C.
1st Railway Artillery Construction Battalion, A.S.C.
Organization and Training Center No. 6, including the Railway Artillery Specialists' School.

Railway Artillery Replacement Battalion,
30th Artillery Brigade (C.A.C.)
    42nd Artillery (C.A.C.)
    52nd Artillery (C.A.C.)
    53rd Artillery (C.A.C.)
    43rd Artillery (C.A.C.) (Attached)
40th Artillery Brigade (C.A.C.)
    73rd Artillery (C.A.C.)
    74th Artillery (C.A.C.)
    75th Artillery (C.A.C.) (Advance School Detachments only)
U. S. Naval Railway Batteries.

III. Organizations of the Railway Artillery Reserve, American Expeditionary Forces, were in action as follows:

UNIT	PLACE	WITH	DATES
1st Echelon R.A.R.	COUSSEY (Vosges)	1st Army American E.F.	19 August 1918 to 27 August 1918.
	MORLAINCOURT (Meuse)	1st Army American E.F.	27 August 1918 to 19 Sept. 1918.
	ST. ANDRE (Meuse)	1st Army American E.F.	19 Sept. 1918 to 13 October 1918.
Hqrs. 30th Arty.	ST. ANDRE(Meuse)	1st Army American E.F.	13 Oct. 1918 to 11 Nov. 1918.
Hdqrs. 42nd Arty. (C.A.C.)	TOUL (Meurthe-et-Moselle)	VIII French Army	13 July 1918 to 9 August 1918.
	MONTREAUX VIEUX	VIII French Army	9 August 1918 to 26 October 1918.
Hdqrs. 1st Bn. 42nd Arty. (C.A.C.)	LA CHAPELLE Sous ROUGEMONT (Alsace)	VII French Army	17 April 1918 to 9 October 1918.
	DANNEMARIE (Alsace)	VII French Army	9 Oct. 1918 to 11 Nov. 1918.
Battery "A" 42nd Arty. (C.A.C.)	LA CHAPELLE sous ROUGEMONT (Alsace)	VII French Army	18 April 1918 to 11 Nov. 1918.
Battery "B" 42nd Arty. (C.A.C.)	LA CHAPELLE sous ROUGEMONT (Alsace)	VII French Army	18 April 1918 to 11 Nov. 1918.
Hdqrs. 2nd Bn. 42nd Arty. (C.A.C.)	Foret de ST. PAUL (Meurthe-et-Moselle)	VIII French Army	12 Sept. 1918 to 25 Sept. 1918.
Battery "C" 42nd Arty. (C.A.C.)	Butte du MESNIL (Marne)	IV French Army	10 Feb. 1918 to 14 Feb. 1918.
	Bois de MENIL La Tour (Meurthe-et-Moselle)	VIII French Army and 1st Army A.E.F.	5 July 1918 to 25 Sept. 1918.

UNIT	PLACE	WITH	DATES
Battery "D" 42nd Arty. (C.A.C.)	Butte du MESNIL (Marne)	IV French Army	10 Feb. 1918 to 14 Feb. 1918.
	CHAMPENOUX, Foret de ST. PAUL (Meurthe-et-Moselle)	VIII French Army	5 July 1918 to 25 Sept. 1918.
Hdqrs. 3rd Bn. 42nd Arty. (C.A.C.)	SOMME SUIPPES (Marne)	IV French Army	16 April 1918 to 22 Sept. 1918.
Battery "E" 42nd Arty. (C.A.C.)	Butte du MESNIL (Marne)	IV French Army	10 Feb. 1918 to 14 Feb. 1918.
	SOMME SUIPPES (Marne) SUIPPES (Marne)	IV French Army	16 April 1918 to 22 Sept. 1918.
Battery "F" 42nd Arty. (C.A.C.)	SOMME SUIPPES (Marne) COURTEMEONT (Marne)	IV French Army	16 April 1918 to 22 Sept. 1918.
Hdqrs. 52nd Arty. (C.A.C.)	TOUL (Meurthe-et-Moselle)	VIII French Army	11 July 1918 to 8 August 1918.
	AUVE (Marne)	II French Army	10 Feb. 1918 to 14 October 1918.
Hdqrs. 1st Bn. 52nd Arty. (C.A.C.)	THIERVILLE (Meuse)	II French Army	16 Aug. 1918 to 26 Aug. 1918.
	BLERCOURT (Meuse)	II French Army	26 Aug. 1918 to 1 Sept. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	1 Sept. 1918 to 17 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F.	17 Sept. 1918 to 11 Oct. 1918.
Battery "A" 52nd Arty. (C.A.C.)	THIERVILLE (Meuse)	II French Army	26 Aug. 1918 to 26 Aug. 1918.
	BLECOURT (Meuse)	II French Army	26 Aug. 1918 to 1 Sept. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	1 Sept. 1918 to 17 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F..	17 Sept. 1918 to 21 Oct. 1918.
Battery "B" 52nd Arty. (C.A.C.)	THIERVILLE (Meuse)	II French Army	16 Aug. 1918 to 26 Aug. 1918.
	BLECOURT (Meuse)	II French Army	26 Aug. 1918 to 1 Sept. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	1 Sept. 1918 to 17 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F.	17 Sept. 1918 to 2 Oct. 1918.

UNIT	PLACE	WITH	DATES
Hdqrs. 2nd Bn. 52nd Arty. (C.A.C.)	GROSROUVES (Meurthe-et-Moselle)	1st Army American E.F.	5 Sept. 1918 to 22 Sept. 1918.
	HAUDAINVILLE (Meuse)	1st Army American E.F.	22 Sept. 1918 to 11 Nov. 1918.
Battery "C", 52nd Arty. (C.A.C.)	GROSROUVES (Meurthe-et-Moselle)	1st Army American E.F.	5 Sept. 1918 to 22 Sept. 1918.
	HAUDAINVILLE (Meuse)	1st Army American E.F.	22 Sept. 1918 to 11 Nov. 1918.
Battery "D", 52nd Arty. (C.A.C.)	GROSROUVES (Meurthe-et-Moselle)	1st Army American E.F.	5 Sept. 1918 to 22 Sept. 1918.
	HAUDANIVILLE (Meuse)	1st Army American E.F.	22 Sept. 1918 to 11 Nov. 1918.
Hdqrs. 3rd Bn. 52nd Arty. (C.A.C.)	Near SOMME SUIPPES (Marne)	IV French Army	10 Feb. 1918 to 14 Feb. 1918.
	Near CROIX-en-CHAMPAGNE (Marne); near HANS (Marne); near SOMME SUIPPES (Marne), and near JONCHERY-sur-SUIPPES (Marne)	IV French Army	7 April 1918 to 10 Oct. 1918.
Battery "E", 52nd Arty. (C.A.C.)	Near SOMME SUIPPES (Marne)	IV French Army	10 Feb. 1918 to 14 Feb. 1918.
	Near CROIX-en-CHAMPAGNE (Marne); near HANS (Marne); near SOMME SUIPPES (Marne); near JONCHERY-sur-SUIPPES (Marne)	IV French Army	7 April 1918 to 10 Oct. 1918.
Battery "F", 52nd Arty. (C.A.C.)	Near ISSE (Marne); near SOMME-SUIPPES (Marne); near JONCHERY-sur-SUIPPES (Marne)	IV French Army	7 April 1918 to 10 Oct. 1918.
Hdqrs. 53rd Arty. (C.A.C.)	AUVE (Marne)	IV French Army	11 July 1918 to 7 August 1918.
	DOMEVRE (Meurthe-et-Moselle)	1st Army American E.F.	3 Sept. 1918 to 18 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F.	18 Sept. 1918 to 16 Oct. 1918.
	CHARNY (Meuse)	1st Army American E.F.	16 Oct. 1918 to 11 Nov. 1918.
Hdqrs. 1st Bn. 53rd Arty. (C.A.C.)	DIEUE (Meuse)	1st Army American E.F.	5 Sept. 1918 to 18 Sept. 1918.
	Near VERDUN (Meuse)	1st Army American E.F.	18 Sept. 1918 to 11 Nov. 1918.

UNIT	PLACE	WITH	DATES
Battery "A", 53rd Arty. (C.A.C.)	RECICOURT (Meuse)	1st Army American E.F.	18 Sep. 1918 to 16 Oct. 1918.
	CHARNY (Meuse)	1st Army American E.F.	16 Oct. 1918 to 11 Nov. 1918.
Battery "B", 53rd Arty. (C.A.C.)	RIBECOURT (Oise)	III French Army	5 June 1918 to 9 June 1918.
	SOMME DIEUE (Meuse)	1st Army American E.F.	4 Sept. 1918 to 18 Sept. 1918.
	Near VERDUN (Meuse)	1st Army American E.F.	18 Sept. 1918 to 3 Oct. 1918.
	SOMME DIEUE (Meuse)	1st Army American E.F.	15 Oct. 1918 to 11 Nov. 1918.
Hdqrs. 2nd Bn. 53rd Arty. (C.A.C.)	DIEULOUARD (Meurthe-et-Moselle)	VIII French Army	7 August 1918 to 18 Sept. 1918.
	NIXEVILLE (Meuse)	1st Army American E.F.	18 Sept. 1918 to 9 Oct. 1918.
	SOMME DIEUE (Meuse)	1st Army American E.F.	9 Oct. 1918 to 4 Nov. 1918.
	MARBACH (Meurthe-et-Moselle)	2nd Army American E.F.	4 Nov. 1918 to 11 Nov. 1918.
Battery "C", 53rd Arty. (C.A.C.)	GRIMAUCOURT (Meuse)	1st Army American E.F.	7 Sept. 1918 to 19 Sept. 1918.
Battery "D", 53rd Arty. (C.A.C.)	SOMME DIEUE (Meuse)	VIII French Army	30 March 1918 to 12 May 1918.
	BOBECOURT (Oise)	IV French Army	12 May 1918 to 10 June 1918.
	DIEULOUARD (Meurthe-et-Moselle)	1st Army American E.F.	5 July 1918 to 19 Sept. 1918.
	NIXEVILLE (Meuse)	1st Army American E.F.	19 Sept. 1918 to 9 Oct. 1918.
	SOMME DIEUE (Meuse)	1st Army American E.F.	9 Oct. 1918 to 4 Nov. 1918.
	MARBACH (Meurthe-et-Moselle)	2nd Army American E.F.	4 Nov. 1918 to 11 Nov. 1918.
Hdqrs. 3rd Bn. 53rd Arty. (C.A.C.)	BLENOD (Meurthe-et-Moselle)	1st Army American E.F.	5 Sept. 1918 to 19 Sept. 1918.
	VIENNE-le-VILLE (Marne)	IV French Army	19 Sept. 1918 to 25 Oct. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	25 Oct. 1918 to 9 Nov. 1918.
	BLENOD (Meurthe-et-Moselle)	2nd Army American E.F.	to 9 Nov. 1918 11 Nov. 1918.

UNIT	PLACE	WITH	DATES
Battery "E", 53rd Arty. (C.A.C.)	BLENOD (Meurthe-et-Moselle)	1st Army American E.F.	5 Sept. 1918 to 19 Sept. 1918.
	VIENNE-le-VILLE (Marne)	IV French Army	19 Sept. 1918 to 25 Oct. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	25 Oct. 1918 to 9 Nov. 1918.
	BLENOD (Meurthe-et- Moselle)	2nd Army American E.F.	9 Nov. 1918 to 11 Nov. 1918.
Battery "F", 53rd Arty. (C.A.C.)	BLENOD (Meurthe-et-Moselle)	1st Army American E.F.	5 Sept. 1918 to 19 Sept. 1918.
	VIENNE-le-VILLE (Marne)	IV French Army	19 Sept. 1918 to 25 Oct. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	25 Oct. 1918 to 9 Nov. 1918.
	BLENOD (Meurthe-et-Moselle)	2nd Army American E.F.	9 Nov. 1918 to 11 Nov. 1918.
Hdqrs. 43rd Arty. (C.A.C.)	DIEUE (Meuse)	1st Army American E.F.	1 Sept. 1918 to 17 Sept 1918.
	ST. BARTHELEMY (Meuse)	1st Army American E.F.	17 Sept. 1918 to 11 Nov. 1918.
Hdqrs. 1st Bn. 43rd Arty. (C.A.C.)	GRIMAUCOURT (Meuse)	1st Army American E.F.	9 Sept 1918 to 22 Sept. 1918.
	AUBREVILLE (Meuse)	1st Army American E.F.	22 Sept. 1918 to 2 October 1918.
	CHARNY (Meuse)	1st Army American E.F.	2 Oct. 1918 to 19 Oct. 1918.
	REGNEVILLE (Meuse)	1st Army American E.F.	19 Oct. 1918 to 11 Nov. 1918.
Battery "A", 43rd Arty. (C.A.C.)	DIEUE (Meuse)	1st Army American E.F.	10 Sept. 1918 to 22 Sept. 1918.
	AUBREVILLE (Meuse)	1st Army American E.F.	22 Sept. 1918 to 2 October 1918.
	CHARNY (Meuse)	1st Army American E.F.	2 Oct. 1918 to 19 Oct. 1918.
	REGNEVILLE (Meuse)	1st Army American E.F.	19 Oct. 1918 to 11 Nov. 1918.
Battery "B", 43rd Arty. (C.A.C.)	LEROUVILLE (Meuse)	1st Army American E.F.	12 Sept. 1918 to 22 Sept. 1918.
	AUBREVILLE (Meuse)	1st Army American E.F.	22 Sept. 1918 to 2 Oct. 1918.
	CHARNY (Meuse)	1st Army American E.F.	2 Oct. 1918 to 19 Oct. 1918.
	REGNEVILLE (Meuse)	1st Army American E.F.	19 Oct 1918 to 11 Nov. 1918.

UNIT	PLACE	WITH	DATES
Battery "C", 43rd Arty. (C.A.C.)	Near NANCY (Meurthe-et-Moselle)	VIII French Army	1 April 1918 to 15 Aug. 1918.
Battery "D" 43rdArty. (C.A.C.)	MENIL-le-TOUR (Meurthe-et-Moselle) POSTE de VELAINE (Meurthe-et-Moselle) and MANONCOURT (Meurthe-et-Moselle)	VIII French Army	2 April 1918 to 15 Aug. 1918.
Hdqrs. 3rd Bn. 43rd Arty. (C.A.C.)	AMBLY (Meuse)	1st Army American E.F.	1 Sept. 1918 to 19 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F.	19 Sept. 1918 to 24 Oct. 1918.
	REGNEVILLE (Meuse)	1st Army American E.F.	26 Oct. 1918 to 11 Nov. 1918.
Battery "E", 43rd Arty. (C.A.C.)	TILLY-sur-MEUSE (Meuse)	1st Army American E.F.	6 Sept. 1918 to 22 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F.	22 Sept. 1918 to 26 Oct. 1918.
	REGNEVILLE (Meuse)	1st Army American E.F.	26 Oct. 1918 to 11 Nov. 1918.
Battery "F", 43rd Arty. (C.A.C.)	LA REHANNE (Meurthe-et-Moselle)	1st Army American E.F.	17 May 1918 to 8 Aug. 1918.
	GENICOURT (Meuse)	1st Army American E.F.	6 Sept. 1918 to 19 Sept. 1918.
	RECICOURT (Meuse)	1st Army American E.F.	19 Sept. 1918 to 26 Oct. 1918.
	REGNEVILLE (Meuse)	1st Army American E.F.	26 Oct. 1918 to 11 Nov. 1918.
Hdqrs. 40th Arty. Brig. (C.A.C.)	TOUL (Meurthe-et- (Moselle)	2nd Army American E.F.	27 Oct. 1918 to 11 Nov. 1918.
1st Naval Railway Battery	SOISSONS (Aisne)	X French Army	10 Sept. 1918 to 24 Oct. 1918.
	CHAMPENOUX (Meurthe-et Moselle)	VIII French Army	24 Oct. 1918 to 11 Nov. 1918.
2nd Naval Railway Battery	FONTENOY-AMBLENY (Aisne)	X French Army	10 Sept. 1918 to 6 Oct. 1918.
	FLAVY-le-MARTEL (Aisne)	X French Army	6 Oct. 1918 to 24 Oct. 1918.
	CHARNY (Meuse)	1st Army American E.F.	24 Oct. 1918 to 5 Nov. 1918.
	LUNEVILLE (Meurthe-et-Moselle)	VIII French Army	5 Nov. 1918 to 11 Nov. 1918.

UNIT	PLACE	WITH	DATES
3rd Naval Railway Battery	THIERVILLE (Meuse)	1st Army American E.F.	12 Oct. 1918 to 3 Nov. 1918.
	CHARNY (Meuse)	1st Army American E.F.	3 Nov. 1918 to 11 Nov. 1918.
4th Naval Railway Battery	THIERVILLE (Meuse)	1st Army American E.F.	13 Oct. 1918 to 29 Oct. 1918.
	CHARNY (Meuse)	1st Army American E.F.	29 Oct. 1918 to 4 Nov. 1918.
	THIERVILLE (Meuse)	1st Army American E.F.	4 Nov. 1918 to 11 Nov. 1918.
5th Naval Railway Battery	THIERVILLE (Meuse)	1st Army American E.F.	13 Oct. 1918 to 11 Nov. 1918.
1st Prov. High Burst Ranging Section	BELLEVILLE (Meuse)	1st Army American E.F.	23 Oct. 1918 to 11 Nov. 1918.
1st Motor Mobile Repair Shop.	GLORIEUX (Meuse)	1st Army American E.F.	22 Sept. 1918 to 11 Nov. 1918.
2nd Motor Mobile Repair Shop	SUIPPES (Marne)	1st Army American E.F.	25 Sept. 1918 to 24 Oct. 1918.
	GLORIEUX (Meuse)	1st Army American E.F.	24 Oct. 1918 to 2 Nov. 1918.
	TOUL (Meurthe-et-Moselle)	2nd Army American E.F.	2 Nov. 1918 to 11 Nov. 1918.

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New British Battle-Cruisers

The largest warship in the world is now being completed for the British Navy, and is expected to be commissioned in the first half of the year. She is H. M. S. *Hood*, a battle-cruiser, the first of a group of four vessels which may be regarded as developments of the "Queen Elizabeth" type. The displacement is well over 30,000 tons, and the length no less than 894 ft., which is only 7 ft. shorter than the *Aquitania*, the largest British liner afloat. H. M. S. *Tiger*, 698 ft., was the longest vessel in the Navy of 1914, but she is far outclassed by the *Hood*, and even the American battle-cruisers of the "Constitution" type—872 ft. in length—have lost their pride of place. A very high sea speed is aimed at in the *Hood* and her sister vessels. Although no official figure can be obtained, they are understood to be designed for 35 knots, which is likely to be exceeded in service. The machinery consists of geared turbines, supplied, we understand, with steam by Yarrow boilers burning oil only. Great attention has been paid to the protection of the hull against the effect of submerged explosions, which will be absorbed by a modified form of the "blister," or cofferdam system first applied to our large monitors. Notwithstanding her imposing size, the ship has most graceful lines. The "clipper" bows are heavily flared, and the forecastle deck is carried well aft. The main battery comprises eight 15-inch guns, mounted in two-gun turrets, all on the center line, and there is an auxiliary armament of fourteen 6-inch or 5.5-inch guns in an upper-deck battery. The *Hood* has two funnels and two tripod masts, and in appearance is not unlike the *Renown*, except that she has an extra pair of guns astern. The *Anson*, a second battle-cruiser of the same class, is building, but it is uncertain whether the third and fourth ships have yet been laid down.

The Engineer.

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GERMAN NAVAL TYPES

Of the five German battle-cruisers now in custody at Scapa Flow, the latest and most powerful are the *Derfflinger* and *Hindenburg*, which if outward appearance goes for anything, are sisterships. There is, however, some doubt on this point, though the report that the *Hindenburg* carries eight 15-inch guns, as against eight 12-inch in the *Derfflinger*, remains unconfirmed. The *Derfflinger* was laid down at the Blohm and Voss yard, in Hamburg, in March, 1912, and completed a week or two before the outbreak of war. Her dimensions and other particulars are as follows: length (on water-line) 689 ft., beam 95 ft., mean draught 27½ ft., normal displacement 26,600 tons. The propelling machinery consists of "Marine" type—modified Parsons—turbines, driving four screws, and supplied by 18 Schulz-Thornycroft boilers, all of which are coal fired. The contract called for 63,000 horse-power and 26.5 knots, but those figures are nominal only. The maximum fuel supply amounts to no less than 4700 tons, including about 600 tons of oil. Like all German battle-cruisers the *Derfflinger* carries a great weight of armor. The main belt, 12-inches thick, is surmounted by an upper strake of 8 inch armor, above which again is the 5.9-inch battery protected by 7-inch armor. The extremities of the ship are clothed with 4-inch or 5-inch plating as high as the main deck. At each end of the main belt there is a 10-inch transverse bulkhead, and two protective decks are fitted with an aggregate thickness of 7-inches over boiler, machinery, and magazine spaces. The main battery comprises eight 12-inch 50 caliber guns, disposed on the center-line, all the guns having a wide arc of fire. Twelve 5.9-inch Q.F. are mounted in the upper deck battery, and there is a number of 3.4-inch Q.F., including several on A.-A. mountings, in the superstructure. The *Derfflinger* is heavily built up amidships, in contrast to the low freeboard at bow and stern. A large fore tripod carries a fire-control station, in the upper section of which a range-finder is installed. Apparently the boats are housed between the funnels, and handled by derricks, which serve also as searchlight platforms. Unlike the earlier German battle-cruisers, there is nothing beautiful in the lines or general appearance of the *Derfflinger*, which is low-browed and graceless, albeit not without a suggestion of grim truculence in keeping with her character.—*The Engineer.*

BOOK REVIEWS

Radio Communication, Theory and Methods. By John Mills. New York McGraw-Hill Book Co.

A book based on lectures to employees of the Western Electric Company being trained for radio war work, and since adopted as a text by the War Department.

This book contains information concerning modern methods, including much data which cannot be found in any one modern text book.

The book is adapted for use by those who have not had calculus. Some of the most important chapters are almost free from mathematical methods. Fundamental principles and methods rather than detailed instruction are excellently presented, so that this interesting book will be welcomed by those physicists and engineers who have had neither the time nor the opportunity to keep pace with principles involved in modern radio methods.

Map Reading for Aviators Including Aerial Navigation. By C. B. Benson. New York. E. N. Appleton. 5¼" x 7". 56 pp. 15 il.

This is a well prepared treatise, but it takes up in detail only the elements of the subject indicated by the title. Practically the entire subject matter of this book is included both in "Sherrill" and in "Spaulding," although in not quite as detailed form. For use of the artilleryman, this book is considered necessarily elementary and gives only a portion of the subject.

Administration. By Connor, Perron, and West. New York. E. N. Appleton. 6¼" x 9½". 191 pp. Price, $2.00.

This is a reference book on company administration and is well written. The subject matter, with the description of each blank form and an explanation of its use followed by a correctly made out form, is well arranged.

However, due to the many recent changes in the system of company administration and supply, this book is of little value to a person who has no other means of keeping himself informed of these changes.

Military English. Official Correspondence, Orders, Messages, and Reports for Use in Courses Allied to Instruction in Military Science and Tactics. By Lieutenant Percy Waldron Long, Ph.D., U. S. Infantry, former Captain and Adjutant, Harvard R.O.T.C., and Adjutant in the School of Adjutants, Plattsburg; Frank Wilson Cheney Hersey, A.M., Instructor in English in Harvard University; 1st. Lieutenant Harvard R. O. T. C., "Co-Author of English Composition." New York: The Macmillan Company. 5¼" x 6¼". 121 pp. Cloth. Price $0.75.

This book, of convenient shape and size, was prepared to conform to the recommendation of the War Department Committee on Education as contained in the Special Descriptive Circular on English. Its direct purpose, as stated in the preface, is to teach the soldier student, or prospective officer, how to write the correspondence, orders, messages, and reports which will be required of him, and which he will be called upon to understand even if he does not write them. It is admirably designed to accomplish all of this, and, in addition, posesses sufficient literary value by reason of the unusual examples cited to make it of more than average interest; a distinct contrast to most texts on composition and writing. The arrangement and style are excellent.

The first chapter sets forth and emphasises the three principles of military English: precision, clearness, and brevity. Three of its most interesting features are the chapters on "Soldiers' Letters Home," "Operation Orders," and "Famous Orders and Examples of Martial Eloquence." The chapter on "Operation Orders" concerns itself with explanations and illustrations of company orders only. The importance of diaries, both personal and official, is shown by the fact that they are the subject matter of one of the ten chapters of this book. The last chapter quotes letters from Washington down to Marshall Petain's "Order of the Day on the Surrender of Germany, November 12, 1918." Needless to state, it includes examples from that most eloquent of great commanders,—Napoleon.

This book is a worthy addition to the collection of texts on military English and correspondence.

Source Book of Military Law and War-Time Legislation. Prepared by the War Department Committee on Education and Special Training. West Publishing Company, St. Paul, Minnesota.

This book is meant to supply, together with the Manual for Courts-Martial, material for the course in military law and war-time legislation as planned by the War Department Committee on Education and Special Training in the approved program for law schools having units of the S.A.T.C. The work is the result of the attempt by one member of the committee to ensure that students and instructors should find available a collection of select sources, there being no other suitable volume in print so far as is known.

Naval Power in the War. (Revised and enlarged edition). By Commander C. C. Gill, U. S. Navy. New York. George H. Doran Co. 5½" x 8". 302 pp. Profusely illustrated. Price, 1.50.

While this book would probably give the average reader a false impression as to the importance and effectiveness of the Navy 14-inch guns on the Western Front, it does, however, set forth a clear record of the Naval grand tactics of the war, and their results. It will be of great value both to the professional and to the general reader. The book has been adopted by the Academy Board of the U. S. Naval Academy, for use in the history course for midshipmen. The chapters describing submarine operations, the chapter on naval lessons of the war, and particularly the appendix showing the comparative strength of navies, will be of unusual interest to all readers.

BOOKS RECEIVED

Tactics and Technique of River Crossings. By Walter Krueger. New York. D. Van Nostrand Company. 9¼" x 6¼". 253 pp. 105 il. Price $2.50.

Aero Engines, Magnetos and Carburetors. By H. Pollard. New York. The Macmillan Company. 4½" x 6". 84 pp. 31 il. Price, $1.00.

Do's and Don'ts for New Soldiers. By Maj. Harlow Brooks, M.R.C. New York. The Macmillan Company. 4¼" x 5¾". 83 pp. Price, $1.00.

Our Army in a Nutshell. By G. N. Tricoche. New York. George U. Harvey Co. 5¾" x 4¼". 105 pp. Price, $0.60.

Details of Military Medical Administration. By Col. J. H. Ford, U.S.M.C. P. Blakiston's Son & Co. 9½" x 6½". 733 pp. 30 il. Price, $5.00.

Explosives (Properties and Tests) Volume II. Second Edition. By Arthur Marshall. Philadelphia. P. Blakiston's Son & Co. 10" x 8". 795 pp. 80 il. Price, $8.00.

United States Artillery Ammunition. By Ethan Viall. New York. McGraw Hill Book Company. 11¾" x 9". 98 pp. Profusely illustrated.

TNT. Trinitrotoluenes and Mono- and Dinitrotoluenes. By G. C. Smith. New York. D. Van Nostrand Co. 5½" x 8". 133 pp. Price, $2.00.

Naval Hygiene. By J. C. Pryor. Philadephpia. P. Blakiston's Son & Co. 5¾" x 8". 507 pp. Profusely illustrated. Price, $3.00.

Field Artilleryman's Guide. (3-inch gun, 4.7, & 6-inch howitzers). Philadelphia. P. Blakiston's Son & Co. 7¼" x 4½". 381 pp. Profusely illustrated. Price, $1.75.

Army and Navy Uniforms and Insignia. By Col. D. Williams, U.S.M.C. New York. F. A. Stokes Co. 7¾" x 5¼". 302 pp. Profusely Illustrated. Price, $1.50.

Soldiers' War Book. By Capt. T. J. J. Christian, F. A. Kansas City. Franklin Hudson Pub. Co. 6" x 4½". 153 pp. Profusely illustrated. Price, 0.75.

Origin and Significance of Military Customs. By Col. J. A. Moss, U.S.A. Wisconsin. Geo. Banta Publishing Co. 7½" x 5¼". 78 pp. Profusely illustrated. Price, $0.50.

Operation Orders, Field Artillery (A study in the Technique of Battle Orders.) By Lt. Col. H. G. Bishop, F. A. Wisconsin. Geo. Banta Pub. Co. 9¼" x 6¼". 105 pp. 2 maps.

Infantry Training. By Capt. D. F. McDonald, U. S. Inf. Wisconsin. Geo. Banta Pub. Co. 5¾" x 4½". 145 pp.

Military Map Reading and Intelligence Training. By C. D. A. Barber, C.E.F. Ohio. E. C. McKay. 7" x 4½". 179 pp. Profusely illustrated. Price, $2.50.

The New Platoon Instructor. By Capt. T. H. Gillman, C.E.F. Ohio. E.C. McKay. 7" x 4½". 292 pp. Profusely illustrated. Price, $2.50.

Ten Lessons in Bayonet Fighting. By Lieut. S. F. Mashbir, U. S. Inf. Wisconsin. Geo. Banta Pub. Co. 6¼" x 4½". 51 pp. 43 il. Price, $0.75.

The Soldier's Diary and Note Book. New York. Thomas Y. Crowell. Co 5" x 3½". 43 pp. Profusely illustrated.

Tri-lingual Artillery Dictionary, Vol. 1, English—French—Italian. By Edward S. Hodgson. London. Charles Griffin & Company. 4¼" x 3½". 92 pp. Cloth. Price, 5s net.

The English of Military Communications. By W. A. Ganoe, Wisconsi Geo. Banta Pub. Co. 5¾" x 8". 197 pp. Price, $1.25.

Airplane Characteristics. By F. Bedell. New York. Taylor & Co. 6¼" x 9¼". 123 pp. Profusely illustrated. Price, $1.60.

My Tribute to France. By Du Bois H. Loux. New York. Pauline L. Diver, Publisher. 6¾" x 5¼". 87 pp. 12 il. 8 maps. Price, $1.50.

325 Group Contests for the Army, Navy & School. By W. J. Cromie. New York. The Macmillan Co. 5¼" x 7¾". 96 pp. Price, $1.25.

The Soldiers' English and Italial Conversation Book. By W. M. Gallichan. Philadelphia. J. B. Lippincott Co. 5¼" x 3". 128 pp. Price $0.30.

Mathematics for the Practical Man. By George Howe, M.E. New York. D. Van Nostrand Co. 7½" x 5¼". 153 pp. Price, $1.25.

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1918

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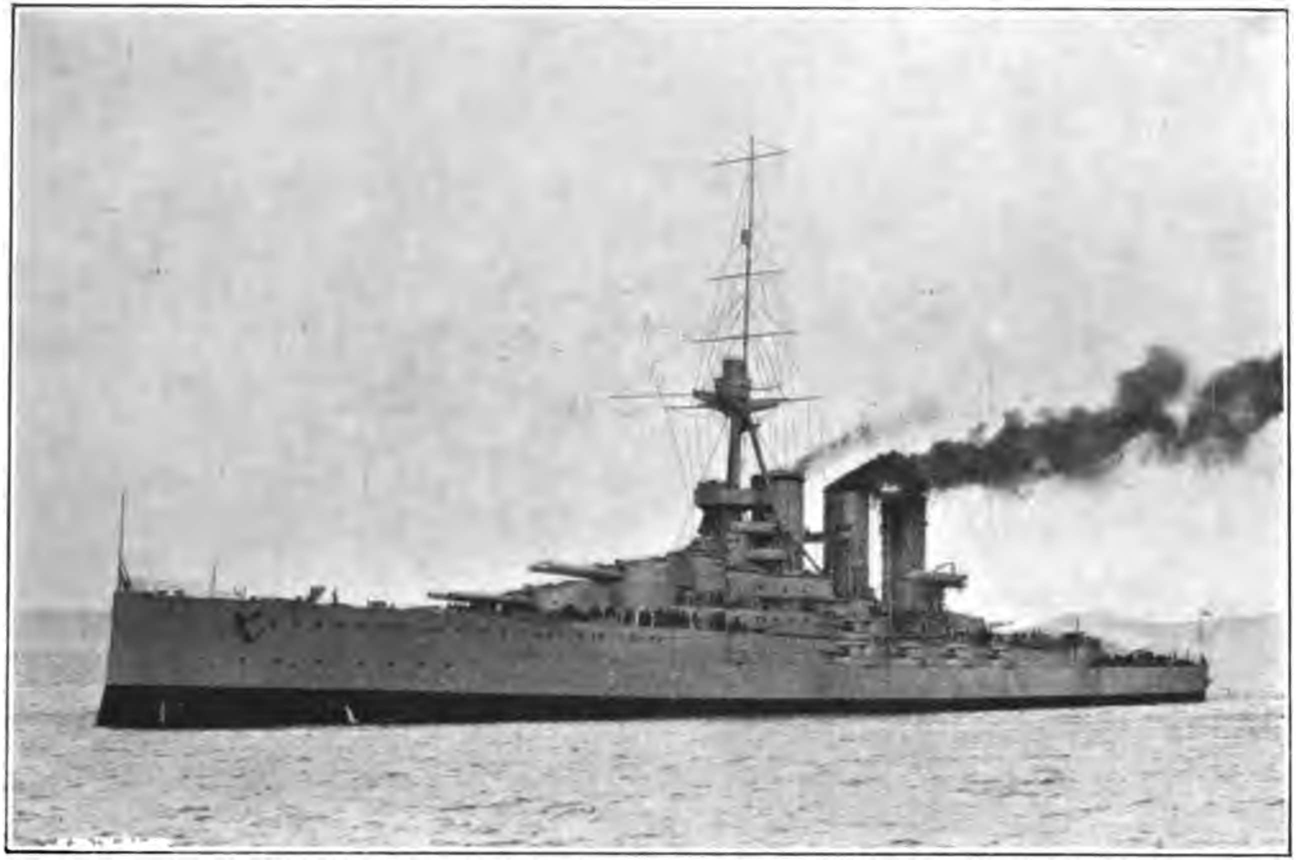

From THE ENGINEER

HIS MAJESTY'S BATTLE CRUISER TIGER

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Use of Railroad Artillery in Coast Defense

By Major Azell Ames, Coast Artillery.

FOREWORD

The writer has never handled railroad artillery and hence the subject matter of this paper consists only of such memoranda and suggestions as have resulted from some years of association with our present harbor defense matériel and with railroad construction, maintenance, and operation.

The purpose of this paper is to discuss some features of the matériel, organization, and training of railroad artillery and its necessary relations to commercial railroad when used in coast defense in the United States. Tactical questions are considered only as affecting the foregoing subjects. It is assumed that mobile artillery has two functions: 1st, to "get there," and 2nd, to shoot. As the Coast Artillery has had for many years much more experience in shooting than in "getting there," attention is devoted principally to this latter function.

Motor-drawn artillery is considered only as to its suitability in situations where the existence of highways would render unnecessary the construction of expensive firing tracks and approaches.

OUTLINE

I. *Tactics*
    a. Principles
    b. Positions.

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  - b. Other rolling equipment.
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III. *Organization and Training*
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IV. *Relation of the Railroad Artillery to Commercial Railroads*

Appendix "A"
Estimate of cost of track per foot.

Appendix "B"
Estimate of cost of engine and train crew service.

I

TACTICS

Principles:

(a) If we are at war with a nation where territory lies overseas, and the nations whose land frontiers adjoin ours are friendly and sufficiently powerful to repel the enemy or neutral and uninvaded, our enemy cannot attack us on land until he has defeated our fleet or neutralized it by superior naval force. He must successfully wage naval war against us before he can safely send against us overseas expeditions of invasion. Our harbor defenses, if adequately developed, by denying to the enemy's fleet the use of our important harbors and preventing the bombardment of our dockyards and naval bases form an important adjunct to our conduct of naval war, but obviously their fixed armament cannot prevent his landing at places out of range of their guns.

If an enemy has obtained sufficient command of the sea to enable him to undertake an overseas expedition against us we may expect him to attempt to cover his landing by fire from ships of considerable gun power and armor protection. The immediate mission of these ships will be to neutralize the fire of the artillery which we shall bring against him sufficiently to enable his transports to land not only his troops and supplies but his own heavy mobile artillery.

Before the present war we have never had a mobile gun ashore of sufficient power to compete with the gun afloat and hence we have been unable to base our defense on any other idea than that the enemy would be able to land under cover of the guns of his ships and that we could hardly expect to successfully attack him until he had moved far enough inland to be beyond the protection of their fire. Today we have available or in sight mobile artillery of sufficient power to engage his guns afloat and furthermore we may be sure that he will have aboard his transports mobile land artillery as good as ours and that if he is permitted to land it and bring it into action we shall, as long as his forces remain within the zone of fire of his fleet, have to compete with both his guns afloat and those he has set ashore. Obviously then instead of saying as before,

"Let him land and get out of the protection of his ship's guns and then go after him," we must now say, "Don't let him land!"

We may hardly expect to obtain the money to provide means for preventing an invasion at every landing place on our coasts, but an invading enemy is going to be very much restricted in the selection of his landing places, not only from consideration of depth of water but primarily from consideration of the military value of the landing places. Our problem would seem to be to provide such a degree of protection that the enemy will have to choose between attempting to land his expeditionary forces at points of high military value against heavy opposition or at points of doubtful military value against less opposition.

Small raiding parties with very light artillery can land almost anywhere and it is no part of the mission of heavy mobile artillery to repel them, but the large amount of heavy material required for a modern invading force necessitates a reasonably good harbor or roadstead and a decent landing place, which can be defended after being seized and from which the invader can move out without too much difficulty against his proper objectives. We have a number of unfortified places on our coasts which would answer his purpose. We also have a number of harbors commercially of some importance which it will not pay to fortify and which would not be worth protecting against an enemy landing party because if our fleet has lost command of the sea our water commerce has been lost with it, but primarily because they are located on portions of the coast where an enemy would have no object in landing because he could cause so little military damage.

Except for cotton and food products, the production of which is so widely scattered as to preclude their destruction being made a military objective, about 80 per cent of our war making power in the shape of coal, oil, iron, and steel and explosives producing plants and other great manufacturing industries is located between Portland, Me. and Norfolk, Va., and within two hundred miles of the coast. Within this area we ought to be prepared to prevent a landing at any point. On the remainder of the Atlantic and Gulf Coasts, except at the entrance to the Mississippi, the landing of large expeditions would be unlikely as being too remote from the principal sources of our war making power. On the Pacific Coast the landing places are less frequent and the harbors susceptible of adequate defense. The importance of this portion of our sea frontier lies in the difficulty of dislodging an enemy, who might, if not prevented from landing, establish himself in the passes of the Rockies and practically cut off all the territory to the west from the remainder of the country. In any territory the ability of the enemy to maintain his vessels off shore, his ability to land his men and materials, to protect them and to move out to attack together with the probability of his selecting that particular place must be the true gage and criterion of our defense measures there. The enemy will always have the initiative in such an undertaking. We must attack him at a point of his own choosing. Be our communications and our information service ever so good they may fail us, especially through enemy activity, at the time we need them most. Our mission is to prevent his landing his forces especially his artillery. In our own artillery capable of combating his naval guns lies our only means of preventing his landing. We cannot shoot until we "get there." The essence of our function in mobility.

It is not to be understood that railroad and motor drawn artillery are not adapted to harbor defense. Their mobility may enable a concentration of gun power on fields of fire not adequately covered by the fixed armaments. Furthermore, the use of such guns and howitzers may have great value against attack of certain harbor forts from the landward side, but nothing can be more fatal to the true performance of its proper function by mobile artillery than to tie it down to or even associate it with locality, to let take root as it were. Once assigned to the defense of a certain place or allowed to establish such associations with seacoast cities as will constitute a claim for local protection and in time of emergency all the great political pressure of powerful local interests will be brought to bear to prevent its removal. Once restricted to the defense of a given position or field of fire by limitations, physical, commercial, or political, its glory has departed, and it has been as much emasculated from the performance of its true function as an ambulance or a fire engine without wheels. If railroad or motor drawn wheeled mounts are found desirable for harbor defense in any locality and are assigned there in time of peace, they should not, for the reason stated above, be considered further as available in any scheme of mobile coast defense any more than the fixed armament of those harbor defenses.

As it cannot be assumed that we shall invariably succeed in preventing the landing of an invading force another argument for the highest mobility presents itself in that we must be able to continue our efforts to prevent the enemy's landing up to the last practicable moment and then be able to rapidly withdraw our heavy mobile artillery to serve its purpose among the artillery of our field armies where it will in general fire at fixed rather than moving targets, being designed and the necessary fire control and accessories provided for either method of fire. It must normally be held at strategic railroad centers as powerful "Masses of Maneuver" ready to be thrown quickly and in strength at the threatened portions of our sea frontiers and equally ready to engage the enemy afloat or ashore.

Naturally the mobility of our artillery will vary in some inverse proportion to its range and power when short haul is considered. Railroad artillery over a long haul should always be able to make better time than motor drawn. Railroad artillery gathered to oppose an enemy landing will not be able to shoot and run as in field operations. It is doubtful if after having taken up positions it will be moved about much (unless he makes a change in point of attempted landing) until the enemy has either been driven off or obtains a sufficiently strong lodgement ashore to threaten its capture, in which event it would be withdrawn and its attack turned to land targets. Information gathered in time of peace will show the enemy the location of all permanent railroad establishments in the region of his proposed landing. In field operations over a wide front there will be plenty of widely distributed targets for railroad artillery that has fired long enough in one place for its position to become known to the enemy. While the enemy may make feints at points other than the one he has selected for his actual attempt to land in force, he will have to concentrate his real power at the latter and we must concentrate to oppose him and depend upon air superiority and the instability of his firing platforms compared with ours, rather than upon any great element of surprise in our attack or change of position to escape punishment. The historical non-success of fleets in silencing fixed shore batteries may offer us some comfort on this score. If we are to have enough heavy artillery to adequately oppose a landing concentrated within the front on which the enemy's ships are likely to fire we shall probably find the number of suitable railroad artillery positions on that front insufficient to permit of extensive changes of position merely to escape his fire.

Observation of fire is going to take a place it has never before had in firing at ships from shore and the flatness of the field of fire afforded by the sea adds an attraction to balloon observation to that already offered by its very direct means of communication by telephone. Against the powerful radio equipment of ships that of air planes is likely to be rendered of small value in reporting artillery observation unless very effective measures for preventing interference are devised. In the strictly field observation subsequent to a successful landing by the invading forces our balloons should prove of more value than in our operations in France as our observers would be working over our own territory with the aspect of which from the air they could acquire great familiarity in time of peace. Of course our balloons will be of little value without an adequate force of fighting planes to protect them. Aircraft will undoubtedly constitute an important part of the equipment of the enemy's expedition. Indeed we may all look to see trans-oceanic flights before we are again brought into war with a foreign power. The enemy can seldom be sure how much we have learned of his plans. Only by the adequacy and timeliness of our air defense can we prevent his knowing our dispositions to prevent their execution and it is probable that only by air superiority can we hope for observation of our long range fire sufficient to make it effective. So much of our coast affords only low sites that even the fire of our less heavy guns will need aerial observation for its correction. Bombing planes should be very effective against naval vessels, transports, and parties attempting to force a landing. Neither our observation nor bombing planes nor our observation balloons will amount to much without an established superiority in fighting planes. We should probably continue for some time to do as in France, depend on the Air Service for planes and balloons and for pilots but furnish most of the observers from our own officers specially trained for the purpose. The proportion of land planes and sea planes in any concentration would be determined by the Air Service. The idea of some system of position finding from balloons suitable even for use in fire against moving targets is not so far beyond possibilities as to exclude it from consideration.

The specialized training required for anti-aircraft artillery will preclude the smaller heavy artillery units providing their own anti-aircraft protection, except such as may be afforded by machine guns. The protection of our heavy artillery used in repelling an enemy landing against raids by the use of light field guns, aircraft, anti-aircraft, and machine guns, and its infantry support are matters which it is not proposed to consider here.

Positions;

(b) The positions from which railroad artillery will fire at enemy ships will probably vary from those selected because of their command of channels and without considering existing commercial trackage, to those in good sized railroad yards already in commercial use. Even at the present cost of track construction, detailed study of the coast will doubtless show places where the building of several miles of tracks purely as firing tracks and approaches is the obvious procedure. We may be able to place some of these tracks in places where their commercial value as railroad feeders might not only conceal the real purpose of their construction but produce a revenue that would go toward their upkeep. Whenever commercial tracks can be used the concealment in time of peace of their intended military purposes is assisted. To build firing tracks in peace time and attempt to conceal them by camouflage or any other artificial construction would be the surest way to disclose their military purpose. Taking advantage of wooded areas in constructing new tracks in peace time, while of little or no value in concealing the location of the tracks might appreciably assist in concealing the presence of the matériel using them. Commercial railroad yards and industrial sidings at or near seaports will probably be our usual firing tracks when firing at ships. Their value to railroad artillery used to augment permanently or temporarily the armament of harbor defense is well shown by a glance at the relation of the N. Y. N. H. & H. and Long Island Railroads to the Coast Defenses of Southern and Eastern New York and Long Island Sound.

It would seem to be the exceptional case where railroad main tracks could be used as firing tracks as they will surely be worked to their utmost capacity in handling troops and other military trains during a concentration at threatened points. There may be situations where the tracks paralleling the shore are too much exposed for this purpose and could be used as firing tracks, the concentration in the immediate region of the threatened point being effected by highways and railroad lines leading toward the shore from interior points. In such cases the uniformity of grade required for main line tracks provides defiladed positions in the railroad cuts and defilade must be depended on for protection where for reasons of economy of concealment of intention parapets are not provided.

Railroad artillery units will probably comprise more motor driven vehicles in the shape of ammunition trucks, portable searchlights, reel carts, automobiles, and motorcycles than are shown in our present tables of organization so that the proximity of highways to the gun positions, especially for ammunition supply is desirable. Where the horizontal base system of range finding is used, access to the base-end stations will seldom be by rail. When once a battery is in position, circulation and supply will be largely by motor vehicles, some by track motor speeders, but mostly by highway. Searchlight stations and tide stations (in situations where tide data is required) are likely to be quite remote from the battery positions. It is not unlikely that positions may be occupied where circulation to outlying stations can best be by water. The folding boats provided for this purpose are likely to prove valuable in the inspection or repair of railroad bridges over streams or arms of the sea. Electric control of searchlights except from the light itself to a nearby protected operating point will involve the transportation of an amount of cable and delay in getting into action that will be unwarranted. The ditches and slopes on the less exposed side of the road bed will afford some protection for communication lines and culverts may be taken advantage of for circulation and cover.

To have a battery of railroad guns or howitzers on carriages not designed for all-round fire, arrive at a position so placed in their train that the breaches rather than the muzzles would be toward the field of fire, or to have to run back several miles on the main line to turn the train on a wye, would hardly be forgiven. Few, if any, railroad turn tables will hold our large railroad gun cars, so that if wye connections are not available or provided at the entrance to approach tracks, forethought and an adequate knowledge of the road are necessary to see that the guns arrive right end foremost.

Railroad guns in position will not usually be protected by parapets constructed for the purpose. Shelters for men and ammunition will usually be dug as in field operations, and the observing, plotting, and command stations will need both concealment and protection. In an emergency where an engineer dump or train is not available to supply material for shelter, a considerable amount of timber, ties, old rail, and structural material may be collected from the railroad which the artillery is using. Existing sidetracks should not be torn up for this purpose unless it is known that they are not to be used in the scheme of concentration or defense. Stone or slag ballasted track may safely be robbed of enough ballast to fill the shallow excavations required for platforms for one or more of our new types of railroad mount. A large amount of wire and posts could be gathered from the fences which enclose the right of way of railroads in our Northern and Middle Atlantic States.

Our standard engineer sand bags weighing empty 62 lbs. per 100 bags are not only useful for revetments of outlying stations to which a considerable quantity may be carried in a side car, but are the best remedy for holding the embankments of firing and approach tracks against washouts. The writer was once able to save the abutment of an important main-line bridge by the prompt despatch of 300 grain sacks and a few balls of marline by gasoline track speeder.

The acquisition of rights of way to firing positions will constitute an important item of the expense of installing firing tracks. In the regions most likely to be selected for a landing those features which give it military value, viz., adequate depth of water, protected anchorage, access to railroad lines, proximity to centers of war material production also give high value to land either for industrial or residence uses. Much of the coastwise railroad trackage is at such a distance from the shore that approach tracks from one to three miles long would be necessary to reach suitable positions for the less heavy guns.

To purchase outright the land necessary will be indicated in some places. Long term leases may be the only means of acquiring some lands except under condemnation proceedings. Whether to buy or lease or whether to build any tracks at all in peace time at places desirable to use for firing positions will have to be made the subject of careful study at each point. In time of war, measures could be readily taken that would be impracticable in peace time; for example, tracks could be very rapidly laid along streets or roads or private drives and the necessary buildings demobilized as a war measure.

The limiting feature in many cases where peace time acquisition of land could be had only at exorbitant cost, would be the time required to do the grading prior to track laying. By accumulating a reserve of track material and tools and making necessary arrangements for labor or use of construction troops at the outbreak or threatening of hostilities, tracks can very quickly be thrown in where there is little grading to do, and by this procedure heavy expenditure for purchase, peace time rental, and upkeep may be avoided. By co-operating with industrial or reality development companies the roadbeds may in some cases be prepared in peace time without their military purpose being disclosed, and the tracks laid only when war is imminent.

MATERIEL

Guns and Carriages.

(a) So far as is known to the writer no motor-drawn guns nor howitzers have been developed up to this time by our Ordnance Department, which are suitable for attacking moving targets, except a 75 mm. gun mounted on a 2½-ton truck and this gun is too light for use against fighting ships, though it might assist in repelling boat attacks or be used against landing parties. Such railroad track and roadbed as would be required for railroad artillery would today cost between $40,000 and $50,000 per mile. In many places highways practicable for motor-drawn artillery exist near our coasts where no railroad trackage is available. It seems certain then that we should develop types of motor-drawn guns and howitzers having arcs of fire of say 60 degrees with traversing platforms or gear suitable for following moving targets. Probably the milage of improved highways along our coasts is increasing many times faster than the railroad trackage. New roads are constantly being built to points on or near the shore while the extension of steam railroad sidetracks or electric railways to shore points is proportionately quite infrequent. It may not be found practicable to develop a motor-drawn gun or howitzer much over 8-inch caliber that can get into action as quickly as is desirable and what is likely to be needed is truly mobile artillery rather than "artillery of alternative position" as there may be little time to spend in placing heavy guns and carriages transported in parts on previously prepared foundations and the very presence of foundations previously built and previously located by the enemy's intelligence department is undesirable.

It is safe to say that from the standpoint of saving in cost of track construction and in saving congestion on the railways in time of threatened invasion, the development of motor-drawn artillery suitable for the attack of ships should be urged. By no means let us be afflicted with tractors that can make but two or three miles per hour on good roads. Motor-drawn artillery that cannot travel fifteen miles per hour on good roads is not worthy of the name. If caterpillar tractors are necessary for pulling guns into position they should be transported on low-hung trucks to the points where they are needed. All wheels of guns or howitzers should be rubber tired to permit of their being hauled at proper speed. Trucks and tractors should be provided with capstans to be driven by the propelling engines through suitable clutches. A much more adequate equipment of spare parts and tools than is reported to have been available in France should be provided.

The following railroad armament capable of being fired over areas sufficient for use against ships and not requiring more than a few hours for installation is understood to be available or under construction:

16-inch Howitzer Model E, on railroad mount, Model 1918, when mounted on a specially laid emplacement in the roadbed. 14-inch Army Rifle, Model E, on R. R. mount when used on foundation of tamped slag, or broken stone in shallow excavation. 12-inch Motor, Model 1890, MI., on carriage Model 1918, on R. R. car Model 1918. MI. (Time necessary for preparation of firing platform not known to writer). 8-inch Seacoast Rifle, Model 1888, Barbette Carriage, Model 1918, on R. R. car, Model 1918 MI. 7-Inch Navy Gun and Pedestal Mount with adapter for use on R. R. car Model 1918 MI.

Probably a howitzer of about 8-inch caliber having a wide arc of fire and a range of 18,000 to 20,000 yards mounted on a railroad car that could be fired from standard truck with portable reinforcement would prove very useful in both seacoast and land operations. A motor-drawn gun approximating the 155 mm. G.P.F. seems very desirable.

While anti-aircraft guns could readily be arranged to fire from such railroad mounts as our railroad cars, Model 1918 MI, it seems probable on account of the positions it may frequently be desirable for such guns to occupy, that greater economy will result from building them for motor-draft and transporting them by rail for long haul. The lighter field guns, trench mortars, etc., need no special adaption for rail transportation. It might be well, however, now that many railroad yards are equipped with travelling cranes to consider loading them by slings to save delay incident to congestion at the available ramps or loading platforms. Naturally the limitations of railroad clearance have to be considered in all designs of railroad artillery equipment or matériel to be transported by rail.

Other Rolling Equipment

(b) The ammunition cars designed by the Ordnance Department seem to be of very good design. The permanent use of the explosive labels of the I. C. C., Bureau of Explosives, is desirable to insure proper habits in handling them.

Plans have been prepared of fire control cars, containing. a plotting room and a coincidence range finder. Where their presence can be concealed they should prove very convenient It is suggested that the design be considered of a metal trough or sled in which the tube of a self-contained horizontal-base range finder can be placed, with light tackle to remove it from its car, to be hauled to a position of greater command than that afforded by the car. A field pedestal could be provided for the tube.

Searchlights will probably in general be mounted on motor trucks. In some instances two high powered lights with their generating plant mounted in a suitable box car with removable sides would provide a convenient unit; the avoidance of having to lose illumination while changing carbons being of importance in seacoast work.

Arrangements for disposal of garbage and excreta from latrines of cantonment cars located for several days in one place will be necessary as well as minor modifications of the lighting, heating, and water supply of cantonment and other cars, due to their longer separation from a base than is common with such cars in commercial use. The sanitary conditions often attending the use of bunk and boarding cars on commercial railroads are far below military requirements.

For fire control and communications as well as for train and carriage lighting electric current will be required. The usual commercial axle lighting systems generating direct current at 32 - 36 volts, should prove very adaptable to our needs, though portable 30-volt gasoline-electric sets will have to be carried in one car of each battery or higher unit trains for use in places where those cars cannot remain at the positions. Tents or other portable wind and waterproof shelters will have to be provided for power plants, switch boards, T. I. devices, plotting outfit, and observing instruments, which may have to be set up and used in the open if time is lacking for sheltered or protected installation. An almost unbelievable amount of equipment can be carried in an ordinary box car if properly stored.

It is suggested that all railroad artillery cars, whether steam heated and electrically lighted or not be provided with a steam train line and an electric train line with proper couplers and jumpers. The electric train line should contain two mains of sufficient copper to enable the storage batteries of electrically lighted cars to be charged from the power unit car, when on account of the cars having been standing for a considerable period the axle generators have been inactive. By simple connections the batteries of any car provided therewith can be cut in to supply the fire control and communication lines. Electric train line couplers could contain a few telephone circuits and should of course be designed so as to prevent errors of connection in coupling. Commercial patterns of such devices, if not exactly suitable for our needs, can form the basis of the needed design. The steam train line suggested above will enable the Baker heaters to be used for heating ammunition cars and if provided with outlets or some steam hose with Siamese connections, heat could be supplied through portable coils to ammunition shelters. Baker heaters could hardly be installed in the ammunition cars themselves.

The U. S. Railroad Administration in co-operation with the railroads has designed a few standardized types of locomotives. The use of these types especially the freight locomotive for artillery trains should save delay and expense in buying and inconvenience in securing repair parts, especially in war time.

Certain cars, generally flats, will be assigned to carry the motor vehicles including ammunition, supply and repair trucks, motor-drawn searchlights and reel carts. Box cars, the removable sides of which can be designed for use as ramps can carry the necessary automobiles and motorcycles with side cars. One of the side cars for the working and security details for each remote station should carry a machine gun.

As all cars will of necessity have air-brakes the pressure system of water supply can be used for kitchen, infirmary, and other cars, though hand pumps should be provided to take care of the condition of the cars being disconnected from a locomotive for considerable periods. For the same reason Baker heaters will be required where steam heating is employed. The use of any water system employing outside tanks, makes steam heat requisite in freezing weather.

As the wrecking equipment of commercial railroads is seldom in excess of its daily demands the higher artillery units, say each brigade should each have a wrecking outfit with a powerful steam crane and accessories. For a like reason, each regiment having to operate in northern latitudes in winter should have a combined snow flanger and plow available.

Fire Control:

(c) Many portions of our shores are so low that position finding instruments mounted on tripods, or mounts of the usual height will be unable to track ships at present day battle ranges because they will be below the horizon. This condition will especially exist where not wishing to disclose the location of our base end or other stations by erecting structures, we simply plant survey monuments there, tie them in to existing landmarks and cover them up. Mobile artillery can hardly be expected to carry with it portable towers of sufficient rigidity to support instruments that have to be carefully levelled or oriented. The extreme case, but not beyond the necessity of consideration is that where enemy ships fire from distances at sea, such that due to the curvature of the earth or atmospheric conditions, they cannot be seen at all from terrestrial stations of any practicable height.

It does not seem at all certain that our present methods of tracking and plotting moving targets will be those we shall use in the not distant future. Possibly study of some of the range finding methods employed in anti-aircraft work may disclose ideas adaptable to the firing of heavy guns. The Navy manages to hit at extremely long ranges and while we prefer to use methods of position finding of greater precision than theirs, we ought to be able to hit ships by their methods if we have to.

With mobile artillery it may be possible to take advantage of existing commercial structures as position finding stations as an offset to the low altitude of the shore. Their very numbers would in many instances cause anyone of them to engage the enemy's attention much less than would a structure which he could recognize as being built solely for military purposes. If we are to continue to use the horizontal base system, the most accurate we are familiar with, it would seem that our base lines to cover the fields of fire from all or most of the desirable positions in the vicinity of probable landing places should be laid out in peace time and the base ends and directing points for probable positions monumented. This base line data could be recorded and a battery commander, as soon as assigned a position, could look up his data and adjust his plotting board, while perhaps miles away from his position. A type of plotting board capable of adjustment of its base line to wide variations of azimuth will be necessary. Adjustable couplers or a number of them marked for their respective base lines would be necessary. For indirect fire the use of the panoramic sight and an aiming point would in the absence of oriented azimuth circles on the gun carriages, be as necessary as in field firing.

Probably one of the most difficult matters to arrange satisfactorily will be the communication lines to base end stations. A lead sheath and a tile duct a couple of feet under ground are not much of a protection against enemy fire and it is probable that our lines located in the open in as sheltered positions as we can find will not suffer much more than corresponding lines in an up to date installation at a harbor fort. They certainly would be much more easy to repair than the more permanent constructions. Reel carts in general would be motor drawn, though a light type of man-hauled cart with broad tired wheels like the beach carts used by the Coast Guard for their shot line gun equipment might be very serviceable in some places. Circulation plans showing tracks, roads, trails, streams, fences, forestation, etc., in the neighborland of positions in its territory should be a part of the equipment of each railroad artillery train in addition to plans of triangulation, base line data, etc. A change from coast to field firing methods would be facilitated if the north of our quadrillage were the zero of azimuth and the co-ordinates of all prominent points along the coast and our selected battery positions more remote form the shore tabulated. Our angular and linear units should be the same for both systems of fire. Our plotting room is quite likely to be in a house or barn and our apparatus including portable lights should be designed.

Ammunition:

(d) Col. Beverly W. Dunn in a letter to the writer states, "I doubt whether your ammunition cars will have any higher temperatures than exist in the limber chests of field artillery. We have no data to show that our explosives have been injured by exposure to these temperatures." He suggests the use of insulating material on the roofs and sides of ammunition cars and allowance for ventilation.

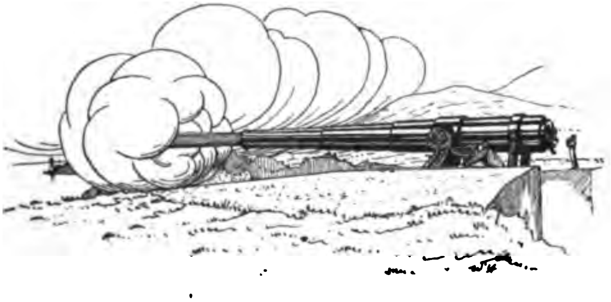
Ammunition in steel box cars even well insulated will be subjected to much more sudden and greater changes of temperature than in the usual seacoast magazines. The precautions for determining power temperature that have been found necessary in the A. E. F. in France should be equally applicable in railroad artillery service here, though our temperature ranges here may be expected to be greater than those encountered there. Our officers returning from abroad speak of a great lack of care in handling projectiles. Those served from railroad ammunition cars can receive all necessary care.

Those brought from railroad stations or dumps by motor trucks are more liable to damage to the rotating bands. It may be found worth while to provide containers for this method of handling which will give more protection than rope grommets.

Damage to tracks from hostile fire, lack of locomotives and congestion of rail lines may frequently require supply of ammunition to railroad batteries in position in excess of their initial supply by means of motor trucks. The number of such trucks shown in our present tables of organization for railroad units would handly be adequate for this service. In any case push cars or track lorries to be moved by man power should be provided to carry ammunition to battery positions either from ammunition cars in sheltered locations or from points at highway crossings where ammunition is brought by motor trucks that cannot reach the positions themselves. Gasoline track cars of the general type used on the railroads for track gangs would save time and man power and are readily carried on flat cars while the batteries are in transit.

* * * * * *

(To be continued)



Types of Railway Mounts

By Lt. Col. L. H. Campbell, Ordnance Department U. S A.
(Captain, Coast Artillery Corps.)

It is the purpose of this article to present in a condensed form, a description of the types of Railway Mounts which will be manned by the Coast Artillery. It is believed that the article will serve as a reference for distinguishing between the various types, and no attempt is made to give more than a very general description of the salient features of each. With the exception of the mounts especially mentioned, all were designed by the Ordnance Department, and are described beginning with the smallest caliber, and not in the order of their conception and design.

All of our railway mounts may be roughly divided into two classes; first, those mounted on a special type of drop frame car, and secondly; those mounted on a special car of the girder type. Of the first type two models were built, known as the Models of 1918 and 1918 MI. The Model 1918 car is provided with hydraulic jacks which lower the car body to the rails and relieve the trucks of the firing load. For transportation the car body is raised from the rails by the hydraulic jacks.

The Model 1918 MI car which succeeded this type depends upon a firing platform for taking the firing load off the trucks. This platform consists of two steel I-beams laid parallel to, and on the outside of the standard rails, and wooden sleepers laid on top of the I-beams at right angles thereto. In placing the car on this firing platform, it is first raised by means of screw jacks. The firing platform is placed in position under the car, and the car body is lowered by the screw jacks to the platform, relieving the trucks of the firing load.

In both the 1918 and 1918 MI cars, outriggers and spades are provided which may be placed at various angles to the car, for transmitting the horizontal component of the firing load to the earth. This type of car is used in mounting the 7-inch guns, 8-inch guns and 12-inch Mortars. The Mortar car is identical with the gun car, with the exception that it is mounted on two 6-wheel trucks instead of two 4-wheel trucks.

With a well trained crew, these cars may be placed in firing position in about fifteen minutes.

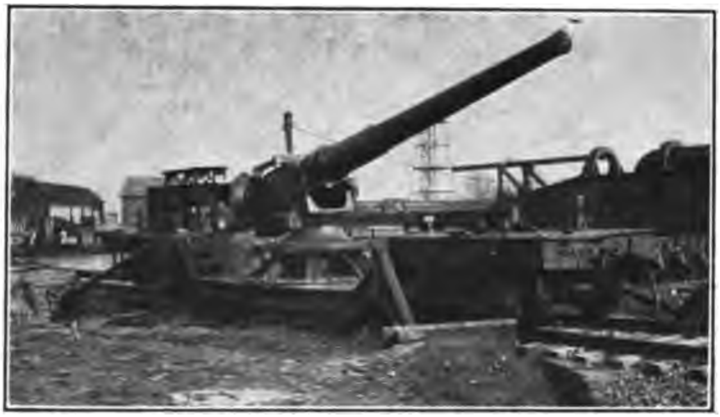


FIG. 1 2304

7-INCH RAILWAY MOUNT ON MODEL 1918 CAR

7-INCH RAILWAY MOUNT

The gun and mount were secured from the Navy Department, and mounted on the standard Ordnance Department Railway gun cars, Models 1918 and 1918 MI.

In order to raise the mount in the well of the car to prevent interference, a sub-base is bolted to the car frame and the pedestal of the carriage mounted thereon. The gravity system of loading is used.

These mounts were not intended for service Abroad, but were built for use along our Coast against submarine raiders. Of course the mount is equally well adapted for field operations. The following data applies to this mount:

Total Weight	171,000 lbs.
Length of Gun	45 calibers.
Muzzle Velocity	2700 f.s.
Range—max. elev. 15° 10′	17,000 yds.
Loading angle	−5°.
Weight of Projectile	165 lbs.
Weight of Powder Charge	58.8 lbs
Traverse	360°.

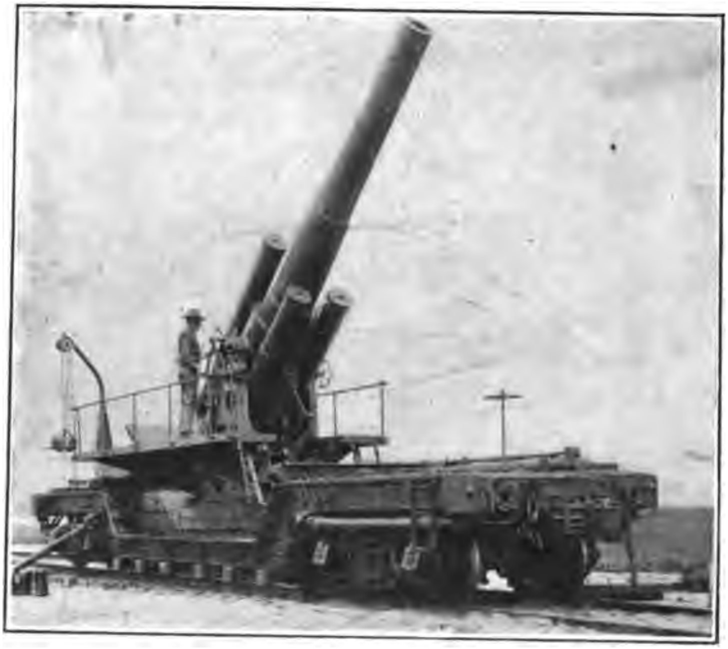


FIG. 2 2265

8-INCH RAILWAY MOUNT, MODEL 1918

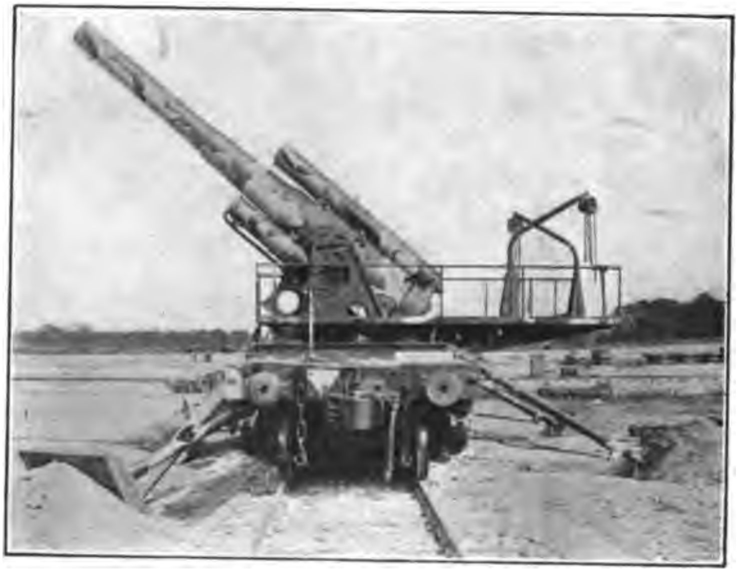


FIG. 3 2266

8-INCH RAILWAY MOUNT MODEL 1918 SHOWING ARRANGEMENT OF OUTRIGGERS

8-Inch Railway Mount, Model 1918

This mount consists of a Barbette Carriage with hydraulic brake and spring-return counter recoil system. This carriage is capable of 360 degrees traverse, the usual type of racer, base ring and traversing rollers being employed. The gunner's platform of structural steel is secured to the side frames and moves in traverse with the racer. This mount is mounted on railway gun car Model 1918 MI.

The gun used is an 8-inch gun which was formerly in use in our Seacoast Fortifications. The 8-inch railway mount, Model 1918 MI is practically the same as the Model 1918, except that it uses an 8-inch Navy gun. Data applicable to this mount:

Total Weight	174,000 lbs.
Length of Gun	35 calibers.
Muzzle Velocity	1950 and 2600 f.s.
Range—max. elev. 42°	20,000 yds.
Loading angle	0 degrees.
Weight of Projectile	200 lbs.
Weight of Powder Charge, max.	65 lbs.
Traverse	360°

10-inch Sliding Railway Mount, Model 1919

The gun used on this mount is a 10-inch gun formerly used in our Seacoast Fortifications. It may be given a maximum elevation of 56 degrees on this mount. The carriage is the French Schneider or glissement type, no traverse of the gun itself being provided and no recoil mechanism being employed.

The mount consists of two box girders rigidly secured together by vertical transoms and longitudinal cover plates. Two sets of 12-wheel trucks provided with hand translating mechanism, support the mount This mount is fired from an epi, in order to secure changes in azimuth. Wooden sleepers on the under side of the mount which are brought into contact with supplemental I-beam rails by means of hand cranks transmit the vertical component of the firing load to the road bed. The friction of the wooden sleepers on the supplemental track when the mount moves to the rear in firing, absorbs the horizontal component of the firing load. Data applicable to this mount:

Total Weight	404,000 lbs.
Length of Gun	34 calibers.

Muzzle Velocity	2400 f.s.
Range 45° elev.	28,000 yds.
Loading angle	+3°
Maximum elev.	56°
Weight of Projectile	510 lbs.
Weight of Powder Charge	150 lbs.
Traverse	Fires from Epi.

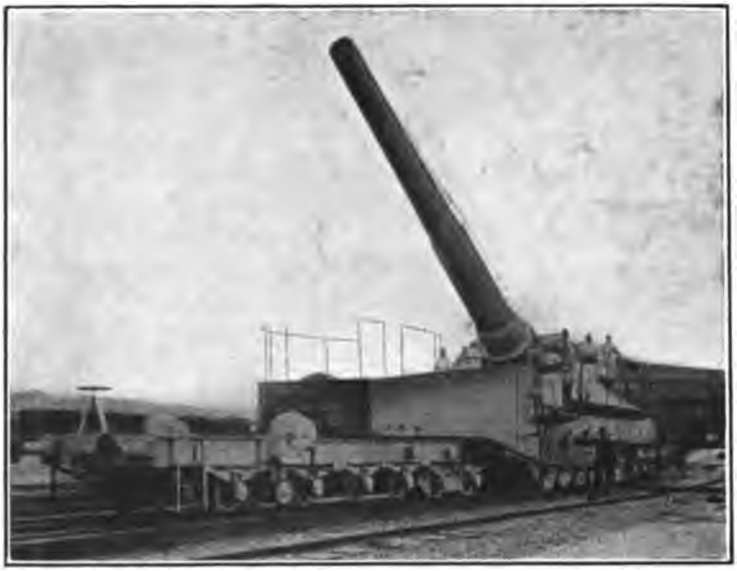


FIG. 4 2267

10-INCH SLIDING MOUNT. MODEL 1919 (FRENCH SCHNEIDER)

12-INCH MORTAR RAILWAY MOUNT, MODEL 1918.

This mount consists of a Barbette Carriage with hydraulic brake and hydro-pneumatic recuperator system. This recuperator is practically the same as that employed by the French on their carriages. The carriage is capable of 360 degrees traverse, the usual type of racer, base ring and traversing rollers being employed. The gunner's platform of structural steel is secured to the side frames of the mount and moves in traverse with the racer. The car used with this mount is the Model of 1918 MI car with two 6-wheel trucks.

The gun used is a 12-inch Mortar which was formerly in use in our Seacoast Fortifications. Data applicable to mount.:

Total Weight	177,000 lbs.
Length of Mortar	10 calibers.
Muzzle Velocity	1500, 1070, 870, 745, 660 f.s.
Range 45° elev.	15,300 yds.
Loading angle	−5°.
Maximum elev.	65°.
Weight of Projectile	700 lbs.
Weight of Powder Charge, max.	65 lbs.
Traverse	360°.

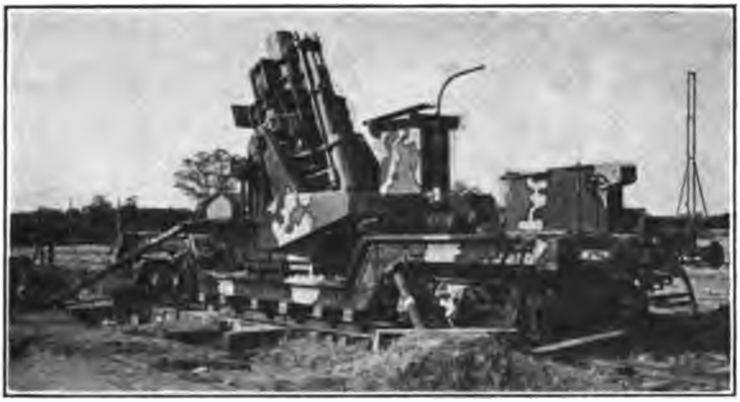


FIG. 6 2268

12-inch Mortar Railway Mount, Model 1918

View from the left rear of the mount with Mortar at maximum elevation. Showing in detail method of placing outriggers and firing platform. While the Mortar is here shown pointing along the track, it may be fired equally as well at any angle therewith.

Illustration No. 6 shows the details of the recuperator used with this and other mounts employing this type of counter recoil system. The recuperator consists of an air chamber "a"; a piston and its packings "b"; a plunger "c" with its yoke "d" and pull-rods "e". The piston and plunger slide in the cylindrical part of the air chamber. The piston rod has a bearing in the front end of the plunger at the point "f". At this end of the plunger the yoke "d" connects it with the pull-rods "e", which in turn are fastened in the front by a bracket "g", and in the rear direct to the sleigh yokes "h". The air chamber "a" is a hollow cylindrical forging fitted with the special water tight bronze liner "i". The plunger "c", of the same material as the liner, is machined to take the piston rod, liquid and stuffing box. The liquid in the plunger is a mixture of water and gylcerine. Upon recoil the plunger and piston move to the rear compressing the air contained in the air

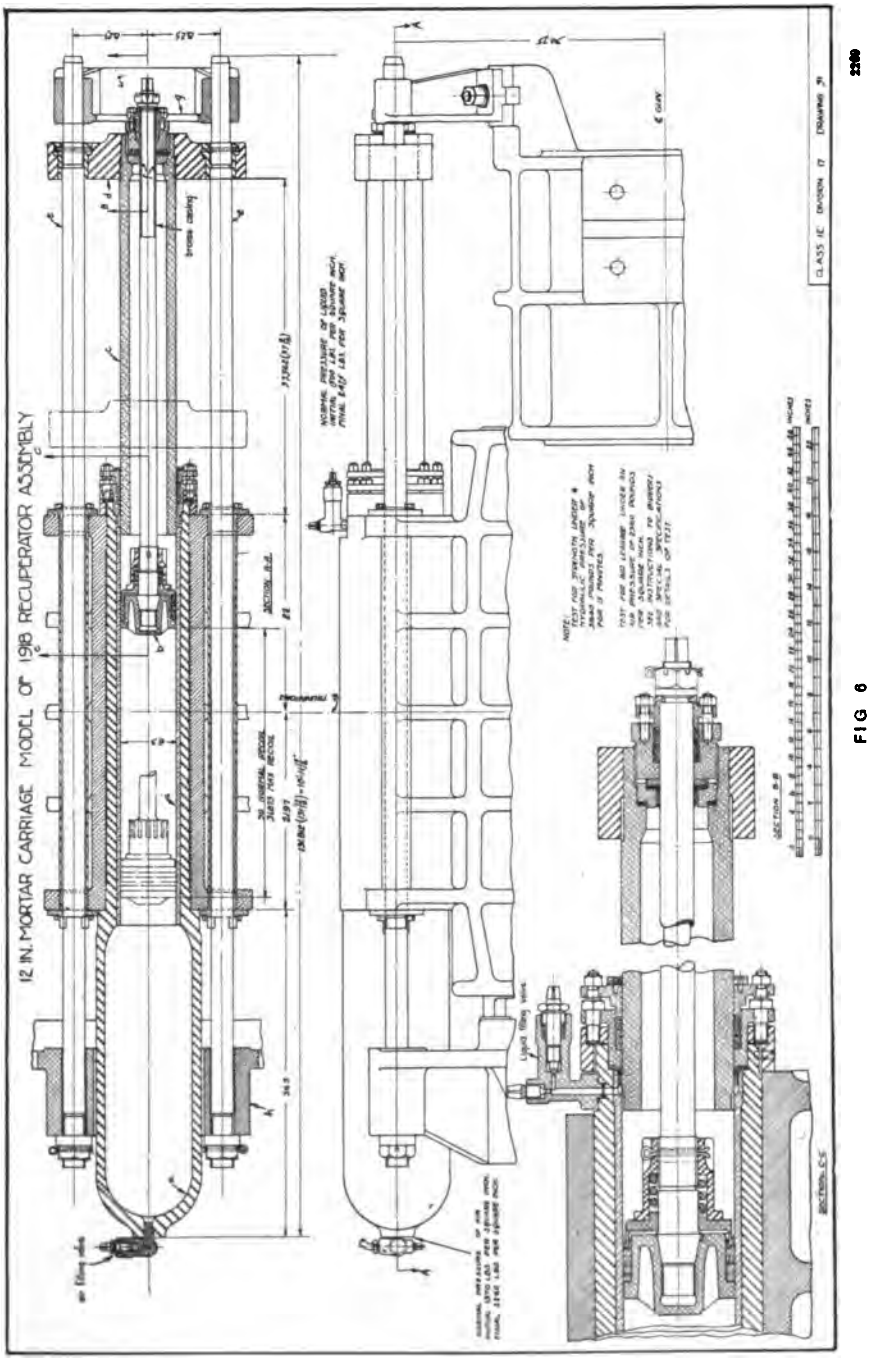

12 IN. MORTAR CARRIAGE MODEL OF 1918 RECUPERATOR ASSEMBLY
SECTION A-A
SECTION B-B
SECTION C-C
Liquid filling valve
Air filling valve
NOTE:
CLASS 1C DIVISION 17 DRAWING 21
2200

FIG 6

chamber. The function of the liquid in the plunger is to act as a seal for the joint between the piston and the liner.

The air chamber is charged to an initial pressure of 1370 pounds per square inch through the air filling valve. The plunger is filled with liquid through the liquid filling valve, to an initial pressure of 1500 pounds per square inch, or at a pressure of about 10 per cent greater than the air pressure of the recuperator. The compression of the air in recoil is sufficient to return the Mortar into battery. In recoil the final pressure in the air chamber is 2260 pounds per square inch and that on the plunger side is 2475 pounds per square inch. The air cylinder is filled through flasks charged to a pressure of 3000 pounds which are carried with the mount after filling at the base. A liquid pump attached to the mount provides for the filling of the plunger with liquid.

12-inch Railway Mount, Model 1918

This mount is the French Batignolles type. The gun is a 12-inch gun which was formerly in our Seacoast Fortifications, and has a maximum elevation of 38 degrees on this mount. The cradle for the gun is fitted with hydraulic brake and hydro-pneumatic recuperator system. The mount is provided with a top carriage in which rest the trunnions of the gun. This top carriage may be traversed 5 degrees either side of normal. The top carriage is supported by the main girders which are carried on two sets of 8-wheel trucks. A ground platform of structural steel is provided for use in firing. In placing the mount in firing position it is run over the ground platform and raised by means of wedges until the load is removed from the trucks. For use along the Seaboard against moving targets where a large traverse is very desirable, the mount may be run over a base ring and racer previously emplaced and quickly prepared for firing. The mount is thus equally adaptable for Seacoast Defense and field operations. Data applicable to mount:

Total Weight	322,000 lbs.
Length of Gun	35 calibers.
Muzzle Velocity	2600 f.s.
Range—max. elev. 38°	30,000 yds.
Loading angle	−5°
Weight of Projectile	700 lbs.
Weight of Powder Charge	275 lbs.
Traverse	10°.

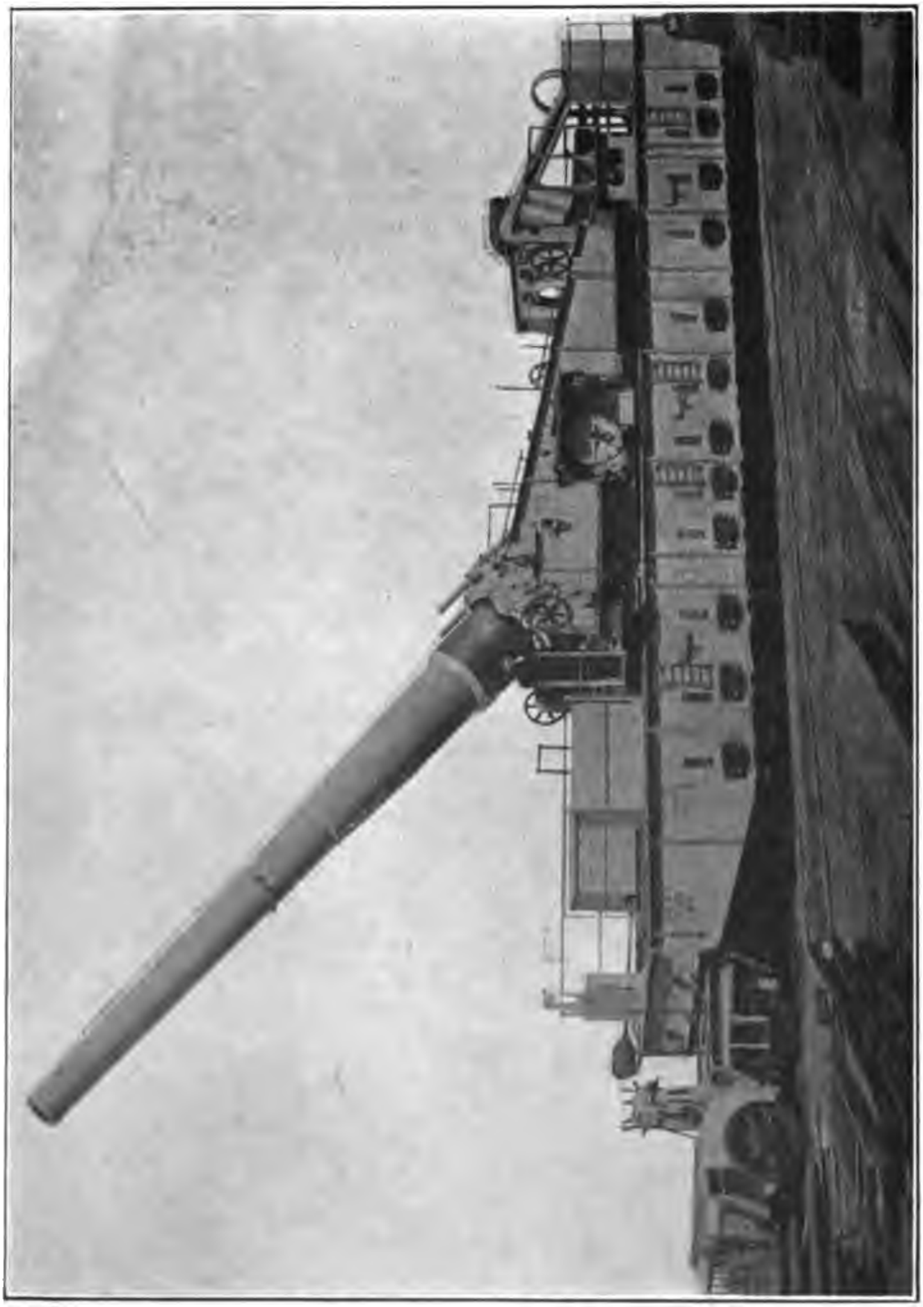


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FIG. 7

12-INCH RAILWAY MOUNT, MODEL 1918

12-INCH SLIDING RAILWAY MOUNT, MODEL 1918

This mount is of the Schneider or glissement type. The gun used is a 12-inch 50 caliber rifle and has a maximum elevation of 40 degrees. No traverse of the gun itself is provided in this carriage. In order to secure the necessary elevation without interference between the breech of the gun and track, it was necessary to move the trunnions some distance from the center of gravity toward the breech. In order to maintain the balance of the gun a counter weight is secured to the breech end.

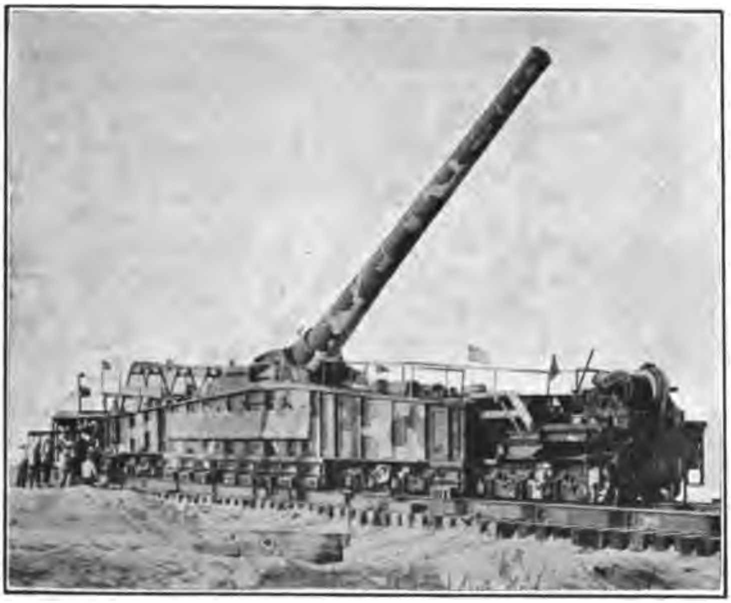
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FIG. 8
12-INCH SLIDING RAILWAY MOUNT, MODEL 1918

The mount itself consists of two box girders rigidly secured together by vertical transoms, longitudinal cover plates and diagonal bracing. The girders are supported by forward and rear span bolsters, which in turn connect two sets of special type 8-wheel trucks. The under side of the girders is provided with wooden sleepers which may be given a vertical movement by means of hand operated wedges.

The loading arrangement on this mount is of the gravity type. It consists of an inclined structural run-way, which carries a projectile tray mounted on small wheels. These wheels move in two channel beams at the top of the structural frame. In loading, the gun is depressed to —4 degrees so that its axis is in prolongation of the axis of the projectile on the tray. The tray is tripped and moves down the inclined rails. Upon reaching the breech face a hydraulic buffer on the projectile tray receives the shock, and the projectile continues to its seat in the gun.

Changes in azimuth are secured by means of moving the mount to any desired position on the epi. In placing the mount in firing position the wooden sleepers above described, are lowered to a hand tight contact with a supplemental track. This supplemental track consists of four sets of I-beams laid parallel to the standard railroad track. A cross section of the epi shows the following arrangement of tracks: two sets of I-beam track placed 6 inches on the inside of the inner standard rail of the curve, and one set of I-beam track on either side of the outside standard rail, about 6 inches therefrom.

These mounts are provided with a hand translating mechanism which consists of a crank adapted to revolve the car wheels through a system of gears, sprockets, and chains. A gasoline winch is mounted on the front end of each mount for the purpose of quickly moving it. A wire cable, made fast to rail clamps ahead of the mount, is wound up on the drum of the winch thus translating the mount.

The vertical component of the firing load is transmitted to the road bed through the wooden sleepers and supplemental track; the horizontal component is absorbed by the friction produced by the movement of the wooden sleepers over the supplemental track during recoil of the mount, which is from four to six feet.

These mounts have been carried over railroads in this country at as great a speed as forty miles per hour.

While this mount has no traverse in itself, it is very probable that experimental firings at moving targets, will prove that it may effectively be used for defense of certain of our harbors which have narrow entrance channels which restrict the movement of a ship. Data applicable to this mount:

Total Weight of Mount	550,000 lbs.
Length of Gun	50 calibers.
Muzzle Velocity	3200 ,2400, 1800 f.s.
Range—max. elev. 40°	45,000 yds.

Loading angle	—4°.
Weight of Projectile	700 lbs.
Weight of Powder Charge	305 lbs.
Traverse	Fires from an Epi.

14-inch Railway Mount, Model E

This mount was designed before the present War and is an experimental type of 360° traverse intended primarily for Seacoast Defense. The mount itself consists of two girders secured together by vertical transoms, longitudinal cover plates and diagonal bracing. The cradle for the gun has a hydraulic brake and spring-return counter recoil system. The projectile is rammed from an ordinary shot truck which runs on the mount.

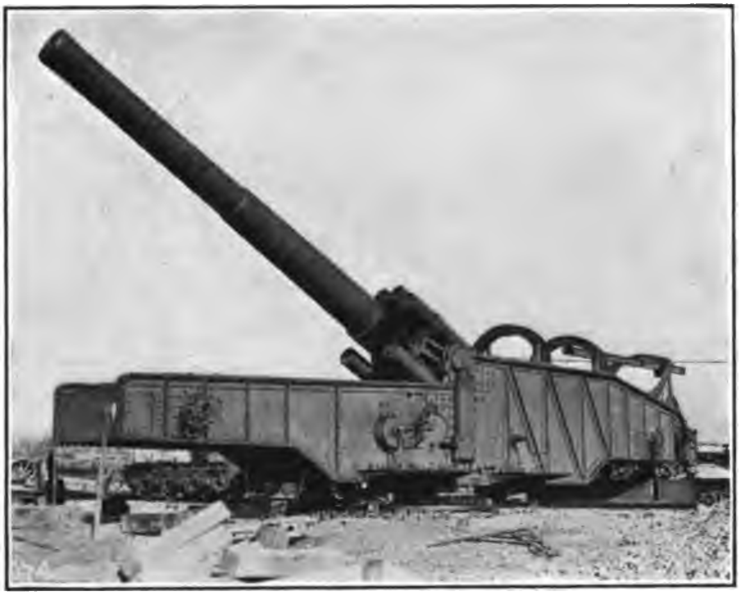


FIG. 9 2272

14-inch Railway Mount, Model E

This mount is adapted to be fired as a glissement type directly from the standard rails of an epi up to 22 degrees elevation, or from a field emplacement to 30 degrees elevation. In firing from the rails steel shoes are bolted to the under side of the girder and bear on the rails. No traverse is secured in this method of firing.

The field emplacement, by means of which 360 degrees traverse may be obtained consists of a cast steel base plate, in two sections, which are bolted together. It is prevented from longitudinal movement by steel spades driven in the ground around its periphery. The top surface of this base plate is machined to provide a roller path, and a traversing rack is secured to its inside flange. A pinion operated by traversing cranks and gears engages in this rack and provides for traversing the mount. Four rollers held in castings are bolted to the underside of the girders and bear on the roller path. Three cast steel segments secured together by through-pins are placed concentric with the base plate in the rear of the mount. The top surface of these castings provides a plane surface on which two shoes, secured to the under rear side of the girders, bear.

The shoes are fitted with hydraulic buffers which absorb the tilting tendency of the mount in firing. These three segments provide for a traverse of approximately 90 degrees and by shifting them, the full 360 degrees of traverse may be obtained. In emplacing this mount the base plate and segment castings are put in place on a bed of gravel or other ballast by means of a locomotive crane. The mount is then run over the base plate and lowered by means of hydraulic jacks located in the trucks until the traversing rollers bear on the base plate. The trucks are removed, and the mount traversed over the rear segment castings.

This mount while an experimental one has conclusively proved the feasibility of obtaining all-round fire for heavy Railway Mounts, thereby making them equally adapted to Seacoast and Field use. Further, it proves that the future rôle of the Coast Artillery Corps is to operate not only along the seaboard, but also as Railway Artillery with the Armies in the Field. Data applicable to this mount:

Total Weight	437,000 lbs.
Length of Gun	40 calibers.
Muzzle Velocity	2900 f.s.
Range—max. elev. 30°	32,000 yds.
Loading angle	0°.
Weight of Projectile	1200 lbs.
Weight of Powder Charge	360 lbs.
Traverse	360°.

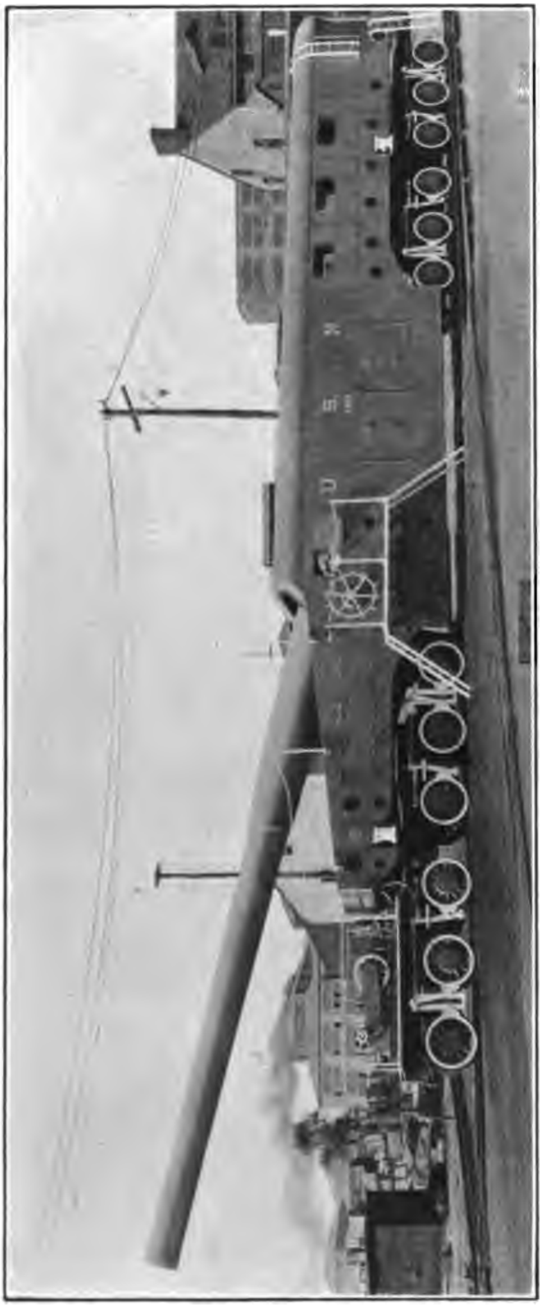


FIG. 10
14-INCH NAVY RAILWAY MOUNT

14-inch Railway Mount—Navy

This mount is the design of the Navy Department and carries a 14-inch 50 caliber rifle, with hydraulic brake and spring return counter recoil system. The mount consists essentially of two box girders with a top carriage, which carries the gun and may be traversed 2½ degrees either side of normal. The girders rest on front and rear span bolsters which connect two sets of special 6-wheel trucks. A cab of light armor covers the entire mount. The mount is adapted to be fired on its trucks between angles of 10 degrees to 15 degrees elevation. Between angles of 15 and 45 degrees it is necessary to place the mount over a pit 9 feet in depth, and to provide a platform to carry the weight of the mount when it is jacked up to relieve the trucks of the firing load. This platform consists of timbers and structional steel placed in position by a locomotive crane.

It appears to be entirely practicable to place this mount on a turn-table to secure all-round fire. By having a series of these turn-tables at various strategic points along the coast, any threatened harbor could be quickly reinforced. The mount has of course already been fired in field service. Data applicable to this mount:

Total Weight	480,000 lbs.
Length of gun	50 calibers.
Muzzle Velocity	2800 f.s.
Range—max. elev. 45°	40,000 yds.
Loading angle	0°.
Weight of Projectile	1400 lbs.
Weight of Powder Charge	460 lbs.
Traverse	5°.

16-inch Howitzer Railway Mount, Model 1918

This mount is of the girder type with hydraulic brake and spring-return counter recoil system. The trunnions are held in steel castings which are secured to the girders of the mount. The girders are of the box type secured together by vertical transoms, longitudinal cover plates and diagonal cross bracing. The side frames above mentioned form a top carriage having a traverse of 5 degrees each side of normal, which is effected by means of a rack segment and pinion. The girder is supported by two special type 12-wheel trucks.

The loading arrangement on this mount is the gravity type and consists of a tray which spans the distance between the projectile box on the loading platform and the breech of the Howitzer. In loading, the Howitzer is depressed to −8 degrees, the projectile is tripped on its tray and slides down the inclined tray to its seat in the Howitzer.

This mount is adapted to be fired on its trucks without any track preparation whatsoever up to angles of elevation of 45 degrees. In firing between 45 degrees and the maximum elevation of 65 degrees, a ground platform and lifting jacks are used. This platform consists of a structure of timbers which are set down in the ground to a distance of about 4 feet. The lifting jacks above mentioned rest on the top of these timbers and lift the mount so that the firing load is taken from the trucks. In addition, two outriggers hinged on the underside of the girders are lowered to bear in shoes which rest on the timber platform. These outriggers prevent the movement of the mount to the rear in firing. A small section of the track must be removed in order to prevent interference with the gun when it recoils in firing.

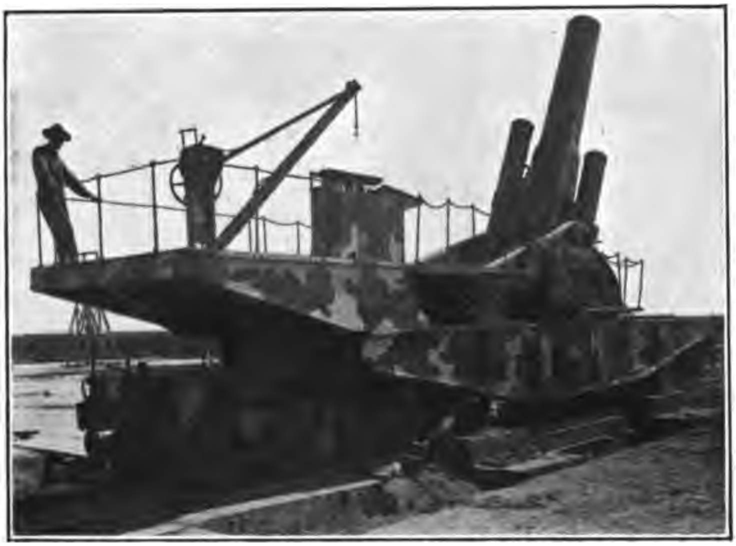


FIG. 11 2274

16-inch Howitzer Railway Mount. Model 1918

It appears to be entirely practicable to secure all-round fire for this mount by means of a base-ring and racer emplaced on a concrete foundation. Data applicable to this mount:

Total Weight of Mount	313,000 lbs.
Length of Howitzer	18 calibers.
Muzzle Velocity	1900, 1360, 1030, 850 f.s.
Range—elev. 45°	23,000 yds.
Loading angle	−8°.
Max. elev.	65°.
Weight of Projectile	1660 lbs.
Weight of Powder Charge	240 lbs.
Traverse	10°.

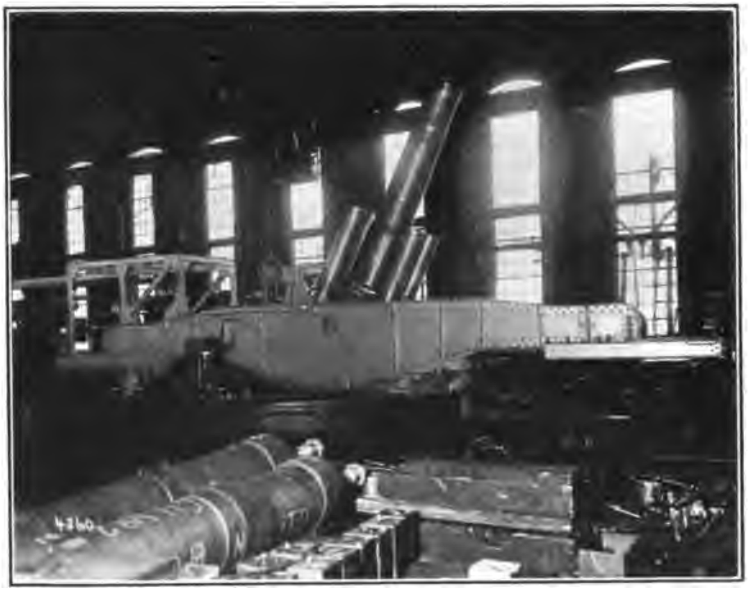


FIG. 12 2275

16-INCH HOWITZER RAILWAY MOUNT, MODEL E

16-INCH HOWITZER RAILWAY MOUNT, MODEL E

This mount is a girder type with hydraulic brake and spring-return counter recoil system. The trunnions are carried in steel-castings bolted to the girders of the mount. These girders are of the box type secured together in the same manner as described for the 16-inch Howitzer Railway Mount, Model 1918. The Howitzer itself has no traverse on the girders. The loading arrangement on this mount consists of an over head trolley which is connected with a similar trolley from the ammunition car. The projectile is picked up by shot tongs in the ammunition car and run over the trolley to the breech of the gun where it is rammed to its seat. The mount is carried on two 6-wheel trucks.

A traverse of 360 degrees is secured by means of special sets of trucks and a base ring, consisting of two cast steel semi-circular sections which are bolted together. On the top of the base ring an annular flange with a clip surface is formed. On either side of this annular flange and concentric therewith, a light rail is secured to the base plate. These rails are adapted to receive four small 4-wheel trucks. Two of these trucks, which are termed radial trucks, are bolted to the under side of the girders; the other two, called traversing trucks, are placed on either side of the mount at right angles therewith, and are connected to the radial trucks by means of steel connecting rods. The wheels of the traversing trucks may be revolved by means of hand cranks and gearing, thus providing for traversing the entire mount. Clips on the radial trucks, which are placed under the mount, engage the clipped surface of the annular flange above mentioned.

In preparing this mount for firing, the base ring is emplaced and the mount run over it on its travelling trucks. The mount is then jacked up, the travelling trucks are removed and the radial trucks are bolted to the girders. The mount is then lowered to the circular traversing track. The two traversing trucks are placed on the track and connected to the radial trucks by means of the connecting rods above described.

This mount is an experimental one, and was designed for Seacoast Defense and not for use Abroad. It is, of course, well adapted for use in Field operations.

ARMAMENT–TRAIN CARS

Three types of standard cars have been developed for use with railway artillery. The illustration No. 13 shows the Ammunition Car, No. 14 the Supply Car, and No. 15 the Fire Control Car. The ammunition car is fitted with racks for projectiles and powder cans. A differential hoist which runs on a trolley, conveys the projectiles in the car directly to the mounts of the non-sliding type. In the case of the sliding mounts, the ammunition car is placed at some distance in the rear of the mount, and the projectile is brought up by means of a small car, or transbordeur.

The Supply Car is used for carrying spare parts, tools, etc., used with the mount.

The Fire Control Car is fitted with desks, lockers, and filing cabinets for maps and other fire control data.

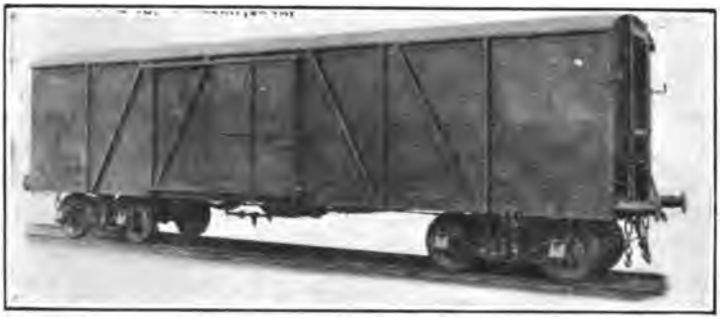


FIG. 13 2276

AMMUNITION CAR

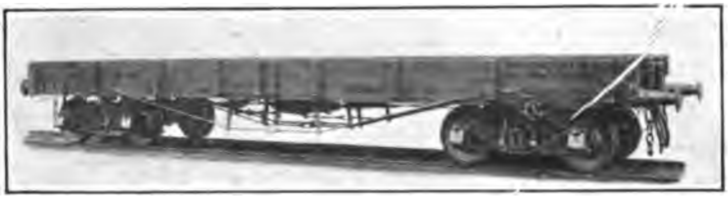


FIG. 14 2277

SUPPLY CAR

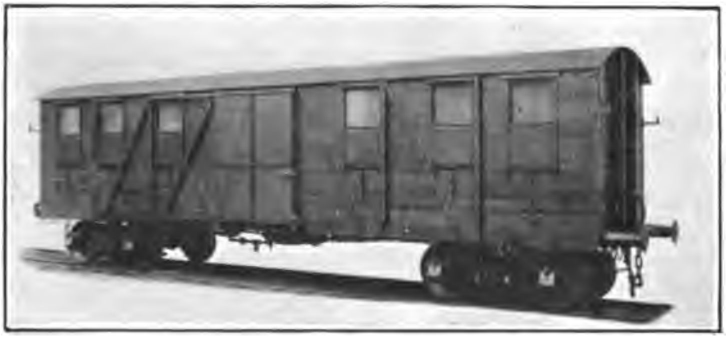


FIG. 15 2278

FIRE CONTROL CAR

NARROW GAUGE EQUIPMENT

The 8-inch railway mount and 12-inch Mortar Railway Mounts may be placed on standard narrow gauge trucks, in order that they may be advanced over track which is easier to lay than the standard broad gauge track. For this purpose a special type of 6-wheel truck has been developed. Two sets of these trucks connected by a span bolster, are placed under each end of the car, after the broad gauge trucks have been removed. The mount may be fired from the narrow gauge track on its firing platform.

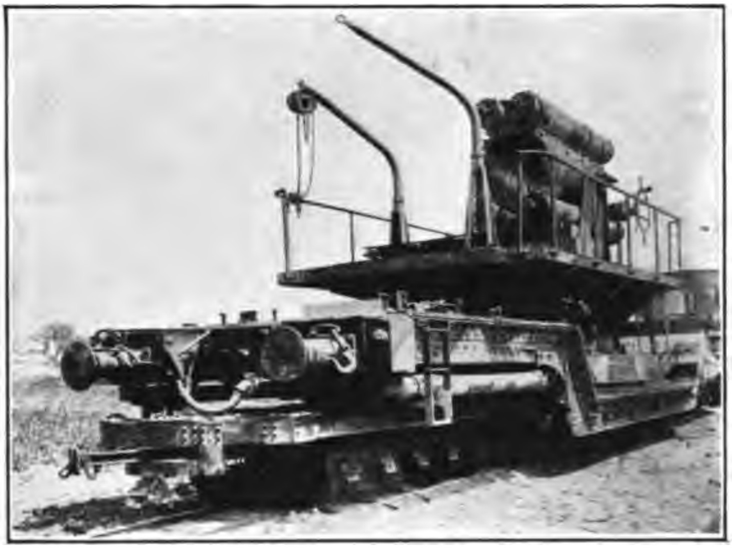


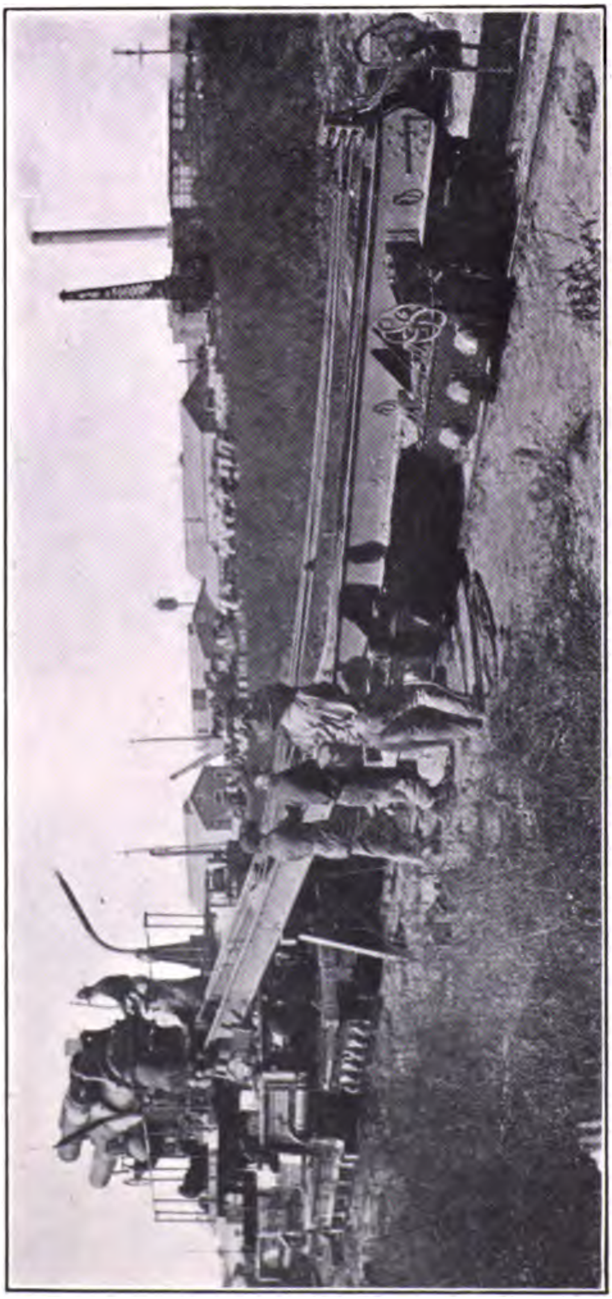
FIG. 16 2279

8-INCH RAILWAY MOUNT ON NARROW GAUGE TRUCKS

In order to run the mount over narrow gauge tracks, it is necessary to remove the gun from its cradle, and to transport it to the front on a special narrow gauge car known as the gun transport car. The illustration shows the method of removing the gun and placing it on the Gun Transport Car which is shown at the right of the picture.

As speeds as great as fifteen miles per hour have been attained by the 8-inch Railway Mount over narrow gauge tracks, it is considered that the use of narrow gauge lines along our seaboard will greatly assist in simplifying the Coast Defense problem.

The type of sight used on all of the above railway mounts automatically compensates for a difference of level of the trunnions, a simple set of linkages keeping the line of sight parallel to the plane of fire as the gun is elevated. Therefore no levelling of the mount is necessary in putting into firing position.



2280

FIG. 17

TRANSFER OF 8-INCH GUN FROM MOUNT TO NARROW GAUGE TRANSPORT CAR.

ROLE AND ORGANIZATION OF TRENCH ARTILLERY.*

By Colonel Forrest E. Williford, C. A. C., Commandant Trench Artillery Center, A. E. F.

This is a brief outline on the Rôle and Organization of Trench Artillery. There is nothing occult about Railway Artillery or Field Artillery, and there is nothing occult about Trench Artillery, so it will not take long to outline the basic principles involved in any of them.

TYPES AND CALIBERS

Let us take up types and calibers. In the first place the mortar, with the catapult as an ancestor, is the oldest artillery weapon which we have. In our enthusiasm over a newer thing, the gun, we had completely neglected the mortar as a field weapon and left it to the Germans to show the necessity for it. They had their minenwerfers ready as early as 1911 and when they opened up with them in late 1914, the Allies found themselves without defense against them.

Of the Allies, the French seem first to have realized the necessity for trench artillery and developed, in turn, the 58 mm. No. 1, 75 mm., old 150 mm., 240 mm. short, 58 mm. No. 2, 340 mm., 240 mm. long, and a new 150 mm. mortar. The first four are now practically obsolete and the 340 mm., because of its inherent difficulties, never was used to any extent.

The British have a 9.45-inch mortar very similar to the French 240 mm. long, from which it was copied. They have also done some developing of their own in the 2-inch, 4-inch, 3-inch Stokes and 6-inch Newton. The first two are now little used but the 3-inch Stokes is at present the standard infantry weapon and is used by the French, Italians, and Americans, as well as the British. The 6-inch Sutton and 11-inch Sutton mortars were designed by a British officer at the request of his government but were developed by the U. S. government. We considered these to be very good but did not succeed in getting any over from the States.

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*Conference at Center of Artillery Studies, Treves, France, January 21 1919.

The Italians also have been active along this line. Very recently I watched tests of an Italian 320 mm. mortar which could be made into a 190 mm. by putting in another tube. They so designed it that it breaks up into a number of loads for convenient mountain transport. Also, they have an ingenuous adapter for their little 65 mm. mountain gun whereby, in effect, it became a medium trench mortar at will.

We thought that the Germans were satisfied with the characteristically German weapon, i.e., wheel mounted, rifled and with hydraulic recoil system, but in late 1917 they put out a flugelminenwerfer which is a very close copy of the French 240 mm. long, and of the same caliber. I suspicion that one reason for this was to enable them to utilize ammunition which they might capture in an advance.

We also though that the French were satisfied with the characteristically French weapons, i.e., smooth bore and direct thrust, but their new 150 mm. Fabry mortar is very much like the minenwerfer except that it is a smooth bore.

Unless you have looked into this subject rather thoroughly you will be surprised to know that there are 23 distinct calibers and types of trench mortars. There are variations and modifications of these so that on the Western and Southern fronts, there were 28 adopted types of trench mortars used by us or against us. Besides these, I have seen experimental but unadopted mortars which brings this total up to about 50.

Caliber.

The Calibers go all the way from 58 mm. to 400 mm. A caliber of 58 mm. or 70 mm. indicates the size of the stem of the bomb and not the size of the bomb itself, which for these calibers is sometimes as great as 7 inches in diameter. All other calibers are for the bomb as well as for the mortar.

Ranges

Maximum ranges vary from about 550 meters for the large D.L.S. bomb of the French 58 mm. to about 4500 for the 11-inch Sutton and Italian 400 mm. mortars. The most prevalent range is about 1500 meters for medium mortars and 3000 meters for heavy mortars.

Rifling

Some are rifled, as are all German minenwerfer, but by far the greater number are smooth-bored. With two exceptions, all the smooth-bored mortars use bombs having a system of vanes (Empennage, the French call it) which keeps the axis of the bomb parallel to the trajectory. The two exceptions mentioned are the Italian 320 mm. Samaia mortar and the 11-inch Sutton mortar. In both of these cases the bombs are ellipsoidal and tumble in flight and, contrary to the expectations of all except the designers, give satisfactory results. This is particularly true of the 11-inch Sutton which is the most accurate mortar in existence today, but this is due to inherent design of the mortars and not to the fact that its bomb tumbles in flight.

Recoil

A few of these mortars, such as the German Minenwerfer and the French 1918, model 150 mm. Fabry mortar, have recoil systems, but all others are direct-thrust weapons, requiring a heavy and more or less elaborate platform to take the shock of discharge.

Transport

The Italian 400 mm. may be transported on its own roller wheels but is more often transported on railway track of some kind. The Italian 320 mm. may be transported on mules or by man power and of course by truck or railway. The German minenwerfer, Austrian 225 mm. and French 150 mm. Fabry have metal beds with attached spades and are transported on their own wheels, the removal of which is about all there is to do in preparing the mortar itself for firing. But all others, and these constitute the majority of the types considered, are without means of transport integral with themselves and have to be hauled in trucks or cars or carried by man power. So we see that the trench mortar of this war was not only not a mobile weapon but that it was not designed for mobility.

Weight of Mortar

The weights of the mortars complete with platform and accessories vary from 108 lbs. to 25,700 lbs.

Weight of Bomb

The weights of the bombs vary from 9.35 lbs. for the 3-inch Stokes to 580 lbs. for the Italian 400 mm. mortar.

Weight of Explosive

The weights of the explosive in the bombs vary from about 2 lbs. in the 3-inch Stokes to about 220 lbs. in the Italian 400 mm. mortar.

Percentage of Explosive

The percentage of explosive in the bomb varies from about 15 per cent in the 76 mm. minenwerfer to slightly more than 50 per cent in the French 240 mm. mortar. In those matériels which we consider to be the most effective, the explosive is rarely less than 40 per cent of the total weight of the bomb except in the case of the 6-inch Newton in which it is 20 per cent. Its mission is different from that of other effective weapons, but I shall speak of that later.

Bomb Filler

In a large number of the calibers, we see only H.E. used and that is more or less proper. In others we also see gas and incendiary bombs, and I should add that the Germans first and the French second, lead in this utilization. Strangely enough, we do not see smoke bombs, but they will undoubtedly come very soon.

Fuses

The fuses are mostly percussion, both instantaneous and short delay, but the Italians have an acid fuse providing for as much as a twenty-four hour delay. Their idea is that they can use their guns to capacity for as long as a day preceding the real attack and thus put over twice the number of bombs that the enemy will put over with the same number of guns. The Germans have a time element in their fuses and the gain is quite evident, particularly for H.E. and incendiary bombs.

Charges

The British 6-inch Newton has the propelling charges in bags, and this is one of the criticisms of this ammunition, but the great majority use brass cartridge cases. The Germans do neither but have a cavity in the base of the bomb which carries the propelling charge. This has the advantage not only of protecting the charge from the weather but, more important still, of having the entire round always assembled in one unit.

These, in brief outline, are the salient characteristics of trench artillery matériel of the world today. I have here a tabulation of data on the more important ones but rather than read it, will include it as Inclosure 1 in the appendix. I recommend a little pamphlet called German Artillery, Part II, Trench Artillery, to anyone who may be sufficiently interested to pursue the subject of matériel further.

MISSION

Some have asked "Why have Trench Artillery at all?" and while they stopped with the question, we searched for the answer. If you refer to trench artillery as we have known it in this war, the question would be well put, and if you refer to the French 58 mm. No. 2, the weapon from which a great bulk of our army formed its opinion, we certainly do not want trench artillery. Even the name, I find, is odious to some who think superficially, or not at all, because it seems to imply trench warfare which is distasteful to all of us. No one can avoid the fact that the great draw-back for trench artillery in this war was its lack of mobility and those of us working with it bent all our efforts to make existing available matériel mobile, the results of which I will later describe.

Let us assume, for the moment, that mobile trench artillery (the mobile mortar, if you will) is to be used and inquire into its mission.

Defensive

First, the defensive from a stabilized position. Let me add that a War Department board recently asked us for our recommendations on trench artillery for the future and in our paper we classified it as follows:

Light, as exemplified by the British 6-inch Newton.
Medium, as exemplified by the French 240 mm.
Heavy, as exemplified by the Italian 400 mm.

so I will use that classification here.

The fire action might take any of the forms which we know as:

a. Barrage.
b. Annihilating.
c. Destruction.
d. Harrassing.

Barrage

The light mortar firing 8 to 10 bombs per minute, each with an effective radius of about 100 feet, can very economically put down an effective curtain of fire through which no troops could be forced. The medium mortar is not appropriate for this class of fire except in the very rare case when you can anticipate a heavy attack at a certain point and can concentrate a large number of mortars at that point solely to get a great volume of fire. The slow rate of fire of the heavy mortar makes it inappropriate for .this work regardless of the concentration that you might be able to make.

Annihilating Fire should be carried out by all kinds of mortars and should be directed against those points where the enemy is supposed or observed to be, with a view to putting him rapidly and decisively out of action. It can also be used against defenses when the latter are to be destroyed quickly. The moral effect is especially great and it should be delivered in bursts, its effect being derived from concentration and rapidity of fire.

Destructive Fire, i.e., deliberate observed fire, should be carried out by all classes against specially important single targets, such as dugouts, flanking defenses, observation posts, machine gun and mortar positions, important sections of trenches, wire, etc. It is obvious that in this, the light weapon should be most called upon for such light work as wire and the heavy weapon for such heavy work as deep dugouts.

Harrassing Fire may be carried out by any type of mortar under specially favorable circumstances to interrupt traffic and hostile activity in general. With the old immobile matériel this class of fire was rarely justifiable unless we were ready and willing to support it by other artillery and that condition now holds to a certain extent with the heavy mortar. The truly mobile light and medium mortars, which can fire and quickly move out, are good for this without support. If the medium mortar is provided with a caterpillar mount as a travelling and firing platform as we have recommended it will be the weapon par excellence for roving harassing fire.

For the defensive in a retreat, the heavy mortar will have no proper function. Heavy destructions which at other times are assigned to it must be assigned to less powerful but longer ranged weapons.

With the medium and light mortars, it is quite another matter. They will have far more power than any gun of anything like equal mobility and weight—such in fact is one of the very strong reasons for having mortars.

The medium mortar on its caterpillar mount can stay near the enemy machine gun range limit and can retreat as readily as does a tank. In this position, it should fire on any observed concentration or put down zone fire on an area which the enemy has certainly occupied. More especially still, its target should be any accompanying artillery. From its position close to the enemy, it can know when our troops have left a certain area or position and deliver fire on the enemy when without it, the enemy would not receive fire for the reason that more distant artillery with poorer liaison cannot risk opening fire on that area.

The light trench artillery being right with the infantry should fire on any concentration of men, whether they be artillerymen, machine gunners, riflemen or what.

With the power which we have in mind for the light and medium mortars and with the fire thus quickly put down on the foremost of the advancing enemy, he will have to be far superior in order to maintain his advance. In any event, they will gain more time for elements farther to the rear and will enable those elements to make better dispositions and take better advantage of the natural features of the ground.

Offensive

Let us next consider the offensive from a stabilized position, in reality the preparation for the coming offensive. This does not differ greatly from its function in the defensive from a stabilized position described above.

Raids into the enemy's lines to get the latest information will become more frequent and the function of the light mortar is to make the necessary destruction in the first line and, above all, to make the necessary passages in the wire entanglements.

For the "jump-off" of what is intended for a large offensive operation the trench artillery can and should do most, if not all, of the destruction of accessory defenses, machine gun and mortar emplacements, for instance, the levelling of the first lines and the cutting of the wire. All types of mortars are appropriate for this work and should be used intensively on it so that the long range artillery can devote its time and ammunition to distant targets, i.e., for actual destructions at strategic points, or to render passage either way across a certain line impracticable.

Continuous Offensive.

Next comes the continuous offensive and the accompaniment of infantry in open warfare. No matériel, either field or trench, which we had available in this war, could do it properly. We saw this need as early as the March offensive and at the signing of the armistice, had an accompanying mortar equipment that can accompany infantry.

The equipment provides for a reasonable supply of bombs drawn in carts to go along with the mortars also drawn on carts. This light trench artillery should be with the infantry and should advance with it. The two commanders should be together in person or, at worst, should have close liaison by runner. When the infantry is checked it will rarely be possible to learn the exact location of the party, machine gun nest, or mortars checking it, and while accurate location is necessary if a field gun or mountain gun with their small projectile is to fire at it, this is not necessary in the case of the more powerful bombs of light trench artillery. In every case a limited zone containing the hinderance can be readily located and it is then the function of the accompanying light trench artillery to sweep this zone, the infantry to continue the advance as soon as the enemy is well under the mortar fire and to rush the position as soon as the mortar fire lifts. This is expensive zone fire, you may say, but not as expensive as you may think, the French having found by actual experience against the Germans on the Aisne beginning November 1, 1918, that in every case, 60 bombs suffices and that a smaller number might have sufficed. Nor is the plan here outlined for the infantry fanciful because it too has been successfully tried.

The prime difficulty for any accompanying artillery is ammunition supply but we have provided both personnel and appropriate carriers for replenishment for this light weapon to *accompany* infantry.

There will be an occasional case on the advance when a more powerful weapon will be needed to reduce a position and this is the function of the 240 mm. mortar, or what may be evolved from it, on the caterpillar mount. I should add that the caterpillar mount has not yet been designed but we today have a 240 mm. mount, designed at the Trench Artillery Center, which not only can but which should be used as stated above for the caterpillar mount.

I have here some rather interesting reports of the French upon the use of their 150 mm. Fabry mortar, about the same power as but less mobile than our improved 6-inch Newton, as accompanying artillery, and also a rather recent report on how the Germans propose to handle the trench artillery question. They will be found in the appendix as Inclosures 2 and 3 respectively.

FUTURE OF TRENCH ARTILLERY

Let us say a few words on the future of trench artillery. If you ask me what the future is I will have to say that I do not know and that while we have fully developed the gun field, we have almost wholly neglected the mortar field. It may be well for me to show that there is a real undeveloped mortar field and to do that I will make use of that old familiar energy formula $E = \frac{MV^2}{2}$. For a fixed amount of muzzle energy I have plotted the velocity against the mass that we may use, taking unity mass at a velocity of 3000 ft. per second, the highest velocity that the U. S. uses in any of its guns. When we come down to 2250 ft. per second, a very prevalent gun velocity for us, we are allowed a mass of 1.77, a 77 per cent increase. Coming on down we have:

Velocity	2000	mass	2.25	
"	1500	"	4.00	And this is the highest velocity which we use in mortars today.
"	1000	"	9.00	
"	800	"	14.00	
"	600	"	25.00	
"	550	"	29.71	And this is the lowest velocity which we use in mortars today.

Thus we see that with the energy it requires for a gun to start a one-pound projectile off at 3000 feet per second a mortar can start a 29.7-pound projectile off at 550 feet per second, these being the limiting velocities which the U. S. uses.

What has all this to do with this subject—just this. In firing against battleships with heavy high quality armor we must have a certain energy if we wish to pierce that armor, and by reference to the expression $\frac{MV^2}{2}$ we see that we can get that energy more advantageously by running the velocity up within reasonable limit than by running the mass up. So, with this class of targets, this alone, without numerous other considerations involved, justifies the gun with its high velocity and relatively low mass projectile. But in land warfare there are few targets which require armor-piercing qualities in the projectile. Necessarily there is a terminal velocity or the projectile would not arrive, but having arrived at the target that terminal velocity is the least valuable property of the projectile except in the few cases where penetration is required. Nor is the mass itself, in so far as it contributes to the remaining energy in the moving projectile, a matter of vital importance. The mass is vitally important but it derives that importance because upon it depends the amount of metal for fragments, high explosive, gas compound, smoke mixture, or incendiary filler which we can put into activity in the immediate vicinity of the enemy and his works. Therefore we see that in a majority of cases we want mass, and not velocity, in the arrived projectile, we see that for a given expenditure of energy we can greatly increase that mass by the simple expedient of a minor decrease of velocity, and we see that there is a real reason, both logical and scientific, for the mortar as opposed to the gun.

This alone justifies at least the through study of the mortar as a field weapon but there are also many economic and tactical considerations involved, some arguing for and some arguing against the mortar.

Tactical

Consider the tactical requirements. There will be a limited number of cases when the projectile must have penetrating energy in order to destroy some strong structure. There will be a great many cases when the need for a long range is paramount to all other considerations. The primary means by which we attain these qualities is by using a high velocity gun and in order to get the high velocity in these cases we are justified in neglecting and over-rising all contradictory features. But do you now think of another case when we would be justified in thus neglecting all other features? I do not.

On the other hand consider the cases when the mortar will do the work equally as well as the gun and, still further, the cases when the mortar can and the gun cannot do the work. Consider the site of our weapon as regards defilade and cover in woods and the mortar with its high angle of departure is favored, but to offset this the greater range of the gun permits greater flexibility in choice of site. When the lines are very close you dare not use a gun for fear of firing on your own men, and the same holds for a poorly defined line such as we always have in a war of movement. When the target is poorly defined, for instance a machine gun nest in a woods, it is folly to use a 75 mm. field or mountain gun and hope for a direct hit if you have some such mortar as the 6-inch Newton to economically, surely and quickly put down a zone fire with more effective projectiles. Also, take the case of a target so completely defiladed that no gun can reach it. In all of these cases the proximity of the relatively short ranged mortars to the infantry gives them an advantage in liaison which I am certain none of you will underestimate.

Economic

Economic considerations, and by this I do not mean merely the cost in dollars and cents, naturally comes after the tactical but we have not an eternal fountain and some time we may have to think of:

1. Cost, as it affects
   (a) Liberty Loans which the people will stand.
   (b) Taxes that all of us will pay in one form or another.
2. Simplicity, as it affects
   (a) Quantity of metal required.
   (b) Quality of skilled workmen available.
   (c) Quantity of skilled workmen required.
   (d) Time to manufacture.
3. Weight, as it affects
   (a) Rail tonnage.
   (b) Water tonnage.
   (c) Mobility and availability in action.

This might be discussed at great length, and all in favor of the mortar, but I will content myself by saying that I I have collected some rather surprising data comparing the 6-inch Newton Mobile mortar, the 75 mm. field gun, 155 mm. Howitzer, 155 mm. gun and the 8 mm. Hotchkiss machine gun.

Mobile Mortar to Accompany Infantry

In our future one of the most important things is a truly mobile mortar to accompany infantry, one which we class as the light mortar. So far no nation has produced one which is wholly appropriate and this has led us to look into the requirements as regards:

1. Range.
2. Weight of weapon.
3. Weight and type of bomb.
4. Features contributing to certainty of action and convenience of service.
5. The best organization for development and tactical use.
6. The co-ordination of its matériel with that of other branches.

In the design of any gun it is necessary to strike a balance between the conflicting factors of range, mobility, and power and the weapon which possesses these three features in the highest degree is the most efficient one. Thus in determining the accompanying mortar it is necessary to provide for sufficient range and power within the weight limit.

As the direct fire gun is the proper weapon for flat open country so is the mortar the weapon for rugged and wooded country and the original definition and conception of a trench mortar might well be changed to a "weapon designed to throw a bomb containing a large explosive charge from a position with high angle defilade against a target similarly defiladed."

The tactics of an army are determined by the terrain in which it is operating, and so is the range of the weapons employed. A flat open country is adaptable for the quick movement of large bodies of troops and give little aid for resistance but do not permit large troop movements and therefore is not the place where decisive battles are fought. The most stubborn resistance of the enemy is to be overcome in country of moderate roughness where tactical necessity demands that the fighting take place from ridge to ridge, so that the main strength of the armies will be behind opposing ridges. A mortar must then have a minimum range that will permit it to take cover behind one ridge and to fire upon targets on the next ridge. Examination of maps of a number of sections of country which is moderately rugged shows that the average distance between ridges is from one mile to one and one-half miles and so we see that a range of about 3500 yards is required for our mobile accompanying mortar if it is to take part in the greatest number of actions.

For this accompanying artillery to be of greatest value in support of infantry it must be capable of going anywhere that infantry can go and at the same speed as the infantry, and to accomplish this the weight will be limited to the following fundamentals:

1. The maximum weight which the average man can conveniently lift is 100 pounds.
2. The maximum weight a man can conveniently carry over rough country is 75 pounds.
3. The maximum weight a man can haul on a pneumatic tired ball-bearing cart over rough country is about 130 pounds (From experiment at Trench Artillery Center).
4. The maximum number of men that can convenienty carry any one pice on a steep slope is 4.
5. The most convenient unit of men, 8.

It is presumed that the mortar and ammunition will be carried as far forward as possible by motor truck, and from there on by hand carts handled by men. If the country becomes too rough for carts then of course the men must carry the mortar and ammunition. The weight thus becomes limited, about 600 pounds for the mortar and 200 pounds for the cart or means of transportation. The weight of any one piece must not exceed 300 pounds and the bulkiest piece must be of such shape that it can be carried by four handles. There are few places that the hand cart cannot be taken and the total weight could be made as high as 1000 pounds, though it would be far better to limit this weight to 800 pounds.

As a feature of mobility also, the mortar should be capable of being quickly and easily assembled under conditions of darkness, wet, and mud, and there should be no small or loose parts to become lost.

The power which the mortar must have will depend upon the class of targets against which it is to be used. Those, in the main, will consist of:

1. Concealed machine gunners, trench artillerymen or automatic riflemen without shelter.
2. Same in shell holes or light shelter.
3. Machine gunners in concrete shelters.

For use against troops in the open the cast iron bomb with instantaneous fuse will be most useful.

With targets of the second and third classes and actual destruction of the shelter would in most cases require too much time. This is not necessary, however, and the advisable course is to make the zone untenable, a condition which is easily obtainable with one or another of the H.E., gas or incendiary bombs, according to circumstances. Smoke bombs too are needed for cases where the enemy must be blinded, such, for instance, as when knowledge of his location is too indefinite to justify zone fire.

Based upon the statement that a fragment weighing .66 ounce (.024 lb.) with a velocity of 580 ft. per second, will kill a man and the fact that there might be 474 human targets in a circle whose radius is 100 feet (the effective radius of the 6-inch Newton bomb) we see that we need 11.376 pounds of metal.

Based upon thorough analysis, of which the above is the briefest outline, and with a view to ascertaining how to modify our present 6-inch Newton mortar, in order to get the best accompanying mortar, we are led to the following salient conclusion about our light mortar:

1. 3500 yards range.
2. 35 to 40 pound bomb.
3. 10 to 12 pound H.E. Capacity in bomb.
4. Smoke, gas and incendiary fillers also.
5. Total weight of complete mortar about 800 pounds.
6. No part to weigh more than 300 pounds.
7. Steel bed with spades.
8. Transported on light carts.

We have no other weapon which is in any way suitable to accompanying infantry so we can inquire into the proper kind of weapon for light trench artillery with little reference to other artillery. By an analysis similar to the above we also ascertain the desirable features for the medium and heavy trench artillery recommended, but they cannot be considered apart from the other artillery which an army should have, and this latter is wholly outside the province of this conference.

Organization

Just another word and that about organization. As you know, we started out with a battery of what we now term light trench artillery per division and a battalion of four batteries of what we now term medium trench artillery per corps. This organization was unsuitable from every point of view and regimental organization was even more necessary than for other arms already well established. My first paper attempting to get a regimental organization was dated Feb. 8, 1918, and it took until Nov. 10, 1918, to convince the proper authorities, for it was on that date that a cable was sent to the U. S. recommending regimental organization. The fact that our own General Staff here was convinced relieves me of the necessity of telling about, and you of the necessity of listening to, the details of why that organization is essential, for I assure you that there was strong opposition and the General Staff had to be shown.

And then the Germans signed the armistice the next day.

Conclusion

In conclusion let me say that:

1. We need a Center for Trench Artillery.
2. We need regimental organizations.
3. We need a light truly mobile weapon to accompany infantry.

And we need many other things for all of which we trench artillerymen bent every effort. These points were important and they are important still, but back of these three are two associated facts which are far more important not only because they are basic, but also because they affect the whole artillery, the whole army, and the whole nation even. These facts are:

1. We have very fully and ably developed the gun and have exploited it at least as far as we are justified.
2. We have almost wholly neglected the possibilities of the mortar as a field weapon.

Officers of your present rank, perhaps many in this room, will be our higher commanders in our next war and will have the attending responsibilities. Further, it is well within limits to say that your part of the responsibilities for a proper armament exists even now, all this apart from personal interest in the manner in which the people back home hate a war loser.

We shall feel fully repaid for all our work along this line if our suggestions to you and others ultimately result in a thorough study of the mortar as a field weapon because we believe that that study will result in field mortars and therefore in a greatly improved and better balanced artillery for our army.

APPENDIX I

Data on Principal Mortars in Use in Europe

Calibers and Type	Armies in which used	Bombs lbs	Explosives lbs	Maximum Range yds.	Weight to transport lbs
3-in. Stokes	U.S. G.B. Italy	9.35	2.09	7.95	108
76 mm. (Old Model) Light Minenwerfer 2.99-in.	Germany	H.E. 10.06 Gas 9.68	H.E. 1.45	H.E. 1148 Gas 1148	220
76mm. (New Model) Light Minenwerfer 2.99-in.	Germany	H.E. 10.06 Gas 9.68	H.E. 145	H.E. 1422 Gas 1203 Message 1422	312
76mm. (New Model) Light Minenwerfer Flat Trajectory carriage	Germany	H.E. 10.06	H.E. 145	995	550
58 mm. No. 2 French	U.S. France Belgium	L.S. 37 D.L.S. 77 A.L.S. 37	L.S. 12 D.L.S. 22 A.L.S. 12	L.S. 1360 D.L.S. 490 A.L.S. 1526	1879
58 mm. Italian	Italy	16 Kg. 36 29 Kg. 63.8 45 Kg. 99	16 Kg. 13.2 29 Kg. 11 45 Kg. 24.2	16 Kg. 720 29 Kg. 817 45 Kg. 485	981
70 mm. Van Duren	Italy Belgium	19 Kg. 42 35 Kg. 77	19 Kg. 132 35 Kg. 37	19 Kg. 926 35 Kg. 436	761
6-in. Newton	U.S. G.B.	50	10	1800	829
6-in. Newton (Mobile) Model 1918	U.S.	50	50	1800	With handcart and accessories 688
150 mm. Fabry	France	37	12	2180	1500
17.5 cm. Old Model Medium Minenwerfer 6.69-in.	Germany	H.E. 121 Incendiary 82 Gas 92.4	H.E. 23	H.E. 1295 Gas 1750 Incendiary 1126	1064

DATA ON PRINCIPAL MORTARS IN USE IN EUROPE (Continued)

Calibers and Type	Armies in which used	Bombs lbs	Explosives lbs	Maximum Range yds.	Weight to transport lbs
17.5 cm. New Model Medium minenwerfer	Germany	H.E. 13 121 K.E. 16 108 Gas 92.4 Inc. 82	H.E. 13 23 H.E. 16 26	H.E. 13 1011 H.E. 16 1268 Gas 1750 Incendiary 1126	1232
225 mm. Austrain Trench Mortars	Austria	Short 143 Long 167	Short 26.4 Long 48	Short 1365 Long 708	800 (Estimated)
9.45 cm. British Trench Mortar	G.B.	152	75 (Estimated)	2400	3400
240 mm. French	U.S. France	183	90	2240	7700
240 mm. Italian	Italy	147	57	4120	
24 cm. Heavy Flugel-Minenwerfer, Long Barrel 9.45-in.	Germany	H.E. 220	H.E. 92.6	2625	
24.5 cm. Old Model Heavy Minenwerfer 9.8-in.	Germany	Short 139 Long 209 Gas 129.8	Short 57.2 Long 101 Gas 50.6	Short 992 Long 612 Gas 1696	1362
24.5 cm. New Model Heavy Minenwerfer 9.8-in.	Germany	Short 139 Long 209	Short 57.2 Long 101	1060	1693
292 mm. Austrian Trench Mortar	Austria	110	28.6	360	264
320 mm. Samia Trench Mortar	Italy	130	77	1526	1980
390 mm. Austrian	Austria	213	79	360	319
400 mm. Italian	Italy	580	220	4470	25.689

APPENDIX II

REPORTS ON 150 mm. MORTARS AS ACCOMPANYING ARTILLERY

The report herewith inclosed on the use made by the 4th Army of the 1st Groupment of the --- Trench Artillery regiment in the offensive operations of November 1-3 and in the detailed operations which preceded it, is forwarded to the General Commanding -- -- -- -- This report was compiled by --------------- of the staff of the --- Division ----- ------ on his return from being attached to the --- Army.

This groupment had been specially trained at Bar-sur-Seine for the War of Movement. G.H.Q. had given instructions to the group of armies of the center that it should be used in a similar manner to the way it had been instructed. Nevertheless, of the 4 groups engaged two only were effectively used from the 1st to the 3rd of November as heavy accompanying artillery and the two other groups took part only in small operations, the rapid retreat of the enemy having made unnecessary the use of the infantry divisions to which they were attached.

As had been forseen the results obtained were very conclusive.

The different objectives upon which the 150 mortars fired were without exception completely and rapidly destroyed and the infantry was able to go forward without difficulty.

These results are due to the characteristics of the trench artillery employed.

1st—Great accuracy and strength of the Model 1917 mortars; the great material and moral effect of its projectiles although its weight (17 kilograms) is 2½ times less than that of the 150 short.

2d—The great facility of handling a battery of 150. The guns and the O.P. are always very near together and communication is thereby rendered easy.

3rd—Great mobility of the 150 whose carts can go anywhere that a machine gun cart can go.

4th—Intimate co-operation between the infantry and trench artillery resulting from the ease with which liaison is maintained between them on the ground.

The action of the trench artillery diminished the losses of the infantry and raised the morale without any doubt, and the losses of the trench artillery during its accompanying action proper were rather small (half of the losses were due to one unlucky shot; a shell hitting a box of grenades and disabling 30 men).

The trench artillery was wisely employed; it was not considered as an infantry gun but as real accompanying artillery and the greatest initiative was left to the group commander.

Some important lessons can be learned from this first trial.

1st—The accompanying unit should be the four piece battery which alone is both mobile and powerful.

2d—The sections armed with infantry weapons have been of great use in protecting the batteries and assisting in their movements.

3rd—The cart of the 150 has proved to be much superior to that of the 50 which is too heavy and too cumbersome.

The ammunition supply of the group should be improved either by means of caterpillars or by an increase in the number of horses. It should be remarked that the transportation of 100 or 120 - 150 mm. bombs, which is about the capacity of a 75 mm. caisson, can be effected by only 6 horses.

The new method of using trench artillery has proved its worth. If the hostilities keep on the use of Trench Artillery should be more general and the infantry should be made acquainted with its capabilities. The term "Trench Artillery" should disappear and in its place should be substituted "Acompanying Artillery" or "Exploitation Artillery"; both these latter names fit closer the new rôle which the Trench Artillery is called upon to play under present conditions.

If the groups had had better facilities at their disposal and if there had been caterpillars for their ammunition supply the results would have been still more satisfactory; those obtained are excellent at least according to the opinions of the battalion commanders of the 86th and 408th Infantry Regiments.

REPORT ON THE USE OF THE GROUPS OF ------ REGIMENT OF TRENCH ARTILLERY PLACED AT THE DISPOSAL OF THE -------- ARMY

Four groups of the------Regiment took part in the attack of the 1st of November and in the advance which followed it.

A detailed report shows what use was made of the 4th and 5th groups in the Division on the south (axis of attack—south-north). Its use was very limited for the progress of the infantry depended only on the forseen retreat of the enemy.

Two groups (2nd and 3rd) occupied a sector of Vouziers and were to take part in the infantry advance (axis of attack—west-east).

On the 5th of November the third group continued its advance; it was in the region of Chatillon-sur-Bar and the detailed report of its operations had not been finished.

The report of the operations of the 2nd group is attached to the folder.

Conclusions

The use of the 2nd group in particular conformed absolutely to the principles laid down in spite of the great difficulties of the ground, little time left to the group commander to make his plans, and the inevitable difficulties of a first trial the trench artillery gave its assistance very efficiently so and in such manner as to provoke general enthusiasm from the infantry (408 and 86th divisions).

The small number of bombs at the disposal of the 4th Army prevented the trench artillery from taking part in the preparation for the attack. This is a serious mistake; it should take an important part in this.

The artillery preparation during the present operations near our infantry especially as the positions of our first lines is often badly known.

At all events it is certain that the ground immediately in front of our infantry is fired on very little or not at all.

If any defenders remain there they are able to hold up the attack.

This is what happened to the----Corps in the sector of the ---- Division and especially in that of the ---- Division in front of Chestres. (In the woods 500 meters east of Chestres the enemy had organized very strong center of resistance which stopped our advance. It can be stated that no shot fell on these defenses). On the contrary the trench artillery, if it arrives two or three days before the preparation can easily fire very closely in front of the infantry being along side the latter and having complete knowledge of the ground and of the position of our lines. (No abnormal short has been noticed with the 150 mm.).

To sum up, the trench artillery can be used to fire on the zone immediately in front of our line of departure up to 500 or 600 meters ahead of our infantry.

It may be estimated that 2500 bombs for a division front will be sufficient for this mission.

During the Advance the trench artillery is the only artillery which, having been able to cross the Aisne during the first 2 days, gave efficient support to the infantry (communication with the left bank of the Aisne was almost continually interrupted).

Each battery had its zone of action (Italian Front) this zone was made necessary on account of the nature of the ground which was wooded and hilly. The group commander retained throughout his own initiative and if necessary was able to concentrate all his batteries on the same objective.

The axis of advance and of liaison were the same; they had been established in advance and battery positions as well with the aid of plan Directeurs and Aerial Photographs.

The order to fire was given by the battery commander after consultation with the battalion commander. *The Duration of the Fire* alone was indicated to the infantry by the battery commander who regulated his ammunition expenditure according to the importance of the objective.

In most cases 10 to 15 minutes firing was sufficient; the infantry moved forward as soon as the fire had lasted the time fixed upon and captured the objective.

All the missions which presented themselves were filled by the firing of a very small number of bombs (40 to 80). There were no group objectives; only battery objectives.

The batteries as they were organized were obliged to stop after 3 days advance. 1 group for each 2 battalions engaged in the attack would be necessary to assure the relief of the personnel and to keep 1 or 2 units in reserve. These units would be engaged in the most favorable sectors, particularly those where the advance is the most rapid, that is to say where the units engaged most quickly become tired out.

The most important difficulty which remains to be solved is that of the supply of ammunition.

The matériel on the other hand is quite easily transported and has given entire satisfaction.

Note on Fabry Trench Artillery

The 150 Fabry Matériel is particularly well suited for the accompaniment of Infantry in wooded country. Its ammunition must not be used up by making it take part in the artillery preparation.

A group of Fabry Trench Mortars consists of three batteries.

A battery in the field consists of four pieces—(8 small carts and 6 ammunition carts each carrying twenty bombs).

The battery is provided with a machine gun section (6 carts).

The horse-drawn carts can go anywhere that the machine gun carts can go.

The missions of the Fabry Trench Mortars are as follows:

1. To assist the infantry in reducing local resistance, strong points, machine gun nests, woods, villages, etc.

2. To fire on enemy troops who are being assembled, in a ravine or under the shelter of a counter-slope for a counter-attack.

The commander of the Trench Artillery group remains with the commander of the Infantry Division, or keeps close liaison with him.

One battery acts with each battalion. The battery commander keeps with the battalion commander but is not under his orders. The latter makes known the infantry's needs.

The Trench Artillery can protect the infantry by its own fire or, can remain ready limbered up, to fire on objectives which are out of range from its original positions.

For the operations under preparation the two right batteries limbered up and the left battery ready to immediately take under its fire the ravine between Hill No. 170 and the Plateau of la Wagnerie if the infantry has any difficulty in getting across it.

In addition to its material effect the moral effect of the bombs on an enemy sheltered in the woods is considerable.

The greatest initiative will be left to the group commander regarding the use of his guns in action.

APPENDIX III

GERMAN REPORT ON METHOD OF HANDLING MINENWERFER

MINENWERFERS IN THE PREPARATION AND PROGRESS OF ATTACKS

A captured document, prepared by the officer in charge of Minenwerfers in the Second Army shows:

(a) The rôle played by Minenwerfers during the attack and during the move forward. (German offensive of March 1918).

(b) The preliminary work necessary.

(c) The action of the horsed companies of divisional minenwerfers and of detachments of light infantry minenwerfers.

(d) Experience gained by the use of this matériel.

Missions

1. The minenwerfers had as their mission to prepare for the assault positions which, on account of their nearness to our lines, could not be fired upon by the artillery, and in addition they were to take under their fire all the objectives that their range permitted them to reach.

The artillery was thus free to perform other missions.

In principle the objectives of the artillery were distinct from those of the minenwerfers.

The positions to be attacked covered a front of 20 kilometers. Only 8 kilometers of the line had to be bombarded and on the other 12 kilometers the fire was directed on the first and second lines and on parts on the third line as well as on points of support, machine guns, minenwerfers, observation stations and flanking positions.

The first line trenches were in general thinly held; the wire was for the most part solid and well built; the second and third lines were well constructed, held in considerable strength and protected by strong wire entanglements.

The fire had to be particularly dense at the points where breeches were to be made in the wire while at other points it was only necessary to neutralize the enemy garrison.

Number of Minenwerfers Necessary

2. To make the necessary breeches it was considered necessary to have one heavy or medium minenwerfer for a front of 25 to 50 meters and along the rest of the line one heavy or medium minenwerfer for a front of 75 to 100 meters.

Besides, it was decided to use 18 light minenwerfers per divisional sector. As the real artillery preparation was not to commence until one hour before the assault there was no possibility of destroying the wire along the whole front; the only thing that was attempted was the opening of large assault gaps.

There were placed in position:

619 medium and heavy minenwerfers
216 light minenwerfers.

3. The Companies of minenwerfers of the attacking divisions were not used during the preparation in order to keep them fresh for the war movement and the important missions that they had to fulfill.

Each company of the minenwerfer battalions had to put into battery from 10 to 12 minenwerfers, heavy or medium, in place of 8 (normal figure). Likewise the companies of divisional minenwerfers, except those of the attacking divisions, used from 15 to 17 minenwerfers (heavy or medium) in place of the ordinary 12. They had to look out for the supply and service of this increased number. There were available in addition half detachments of minenwerfers of the infantry regiments of the attacking divisions, each provided with 6 light minenwerfers. As soon as the attack commenced these half detachments armed with rifles, etc. left their minenwerfers in place and joined their respective regiments.

Arrival of the Minenwerfer Units and Organization of the Command

4. The Chief Minenwerfer Officer of the 2nd Army, who was placed at the disposal of the 18th Army, arrived in the army accompanied by his staff on the 18 February 1918. He was placed under the orders of the general commanding the artillery but had to report personally to the general commanding the army and to his chief of staff.

He had to study the plan of action for units of minenwerfers and was charged with overseeing the preliminary work. He was authorized to obtain verbal information anywhere and was to keep the command constantly informed of the state of advancement of the preparation. From February 22 to 24, there arrived the commanders of battalions of minenwerfers, accompanied by orienteur officers, to begin the detailed preparation.

The battalion of minenwerfers arrived between the 5th and 6th of March; the companies of minenwerfers between the 1st and 16th of March at the rate of two companies per day.

In each sector of an attacking division the minenwerfer units were placed under the orders of the commander of divisional artillery.

In the division the groupings of minenwerfers were not placed under the orders of the commanders of the artillery groupings.

Preliminary Work

5. The work of placing the minenwerfers in position could, as a rule, be done only at night. There were constructed first the shelters for the personnel and ammunition, then the positions for the minenwerfers, wherever the work could be done without attracting the attention of the enemy; finally the ammunition was put in place.

The minenwerfers were not placed in battery until the last few days preceding the attack.

Much attention was paid to camouflaging the work. The minenwerfer units worked with great care and intelligence and as a result this large number of minenwerfers was put into positions without attracting the attention of the enemy. The violent enemy firing during the last week preceding the attack was not directed on the minenwerfer emplacements, but further to the rear.

On the 19th of March all minenwerfers with their ammunition were in position.

6. It was not possible to do any adjusting before the attack, without arousing the suspicions of the enemy, for the minenwerfers of the divisions in line had not fired for some time. It was decided that adjustments would not take place until the day of the attack, during the fire for effect of the artillery.

7. The preparation included the following periods:

4 hours 40 to 5 hours—surprise fire on enemy minenwerfers,

in which took part those of our minenwerfers within good range. The others fired on objectives whose destruction was necessary before the attack.

5 hours 30 to 5 hours 40—surprise fire on the objectives mentioned in the last line above.

7 hours 10 to 8 hours 40—adjustment was to take place during this period, but the thick fog made observation impossible.

Destruction firing in certain sectors on points of support and important obstacles.

8 hours 40 to 9 hours 40—destruction firing.

9 hours 40—the assault.

Only the light minenwerfers took part in the creeping barrage, making one jump only of 300 meters.

Results

8. As the front line trenches were only thinly held the principal mission of the minenwerfers was the destruction of the wire. Large and numerous gaps were made which permitted the assault troops to advance rapidly.

Experiences Gained

9. (a) The battalions and companies of minenwerfers arrived in plenty of time, as well as the reinforcement minenwerfers and ammunition.

It would have been desirable for the Chief Minenwerfer Officer to have arrived one or two weeks earlier.

The time necessary for arrival before an attack is, then—arrival of minenwerfer units and ammunition from 2 to 3 weeks before the attack; arrival of reinforcement minenwerfers 2 weeks before the attack; arrival of the Chief Minenwerfer Officer 6 weeks at least before the attack.

(b) The number of minenwerfers used and the length of bombardment was sufficient. In case the first line trenches are strongly held it will be better to destroy the wire along the whole front.

(c) Successful results were obtained without adjustment. All the firing was prepared using only the plan directeur; however, if possible, fire should be adjusted before the day of the attack and better results will be obtained.

Use of Companies of Horse Drawn Divisional Minenwerfers and Detachments of Light Infantry Minenwerfers

It has been proved that the horse drawn minenwerfer units give invaluable aid to the infantry; also, we are much superior to the English and the French, not only from the point of view of accuracy of matériel, but also from the point of view of the possibility of its use in the war of movement.

During the period which followed the attack of the 21st of March the French utilized minenwerfers for the first time for their counter-attack on the 6th day of April, for which the preparation lasted several days; as for the English, after the 21st of March they used no minenwerfers on the front of the 18th Army.

The medium horse drawn minenwerfers placed under the orders of the commanders of infantry regiments have been often used during the attack and with very good results.

The minenwerfer companies followed the first line infantry very closely. As a result they were ready to open fire as soon as they received the order designating their missions. It often happened that they were brought into action solely on the initiative of their commanders.

Their principal mission was to support the infantry during the attack of towns and other centers of resistance and to neutralize machine gun nests.

The result desired was obtained after a fire of an average of an hour, and sometimes a few shots were sufficient. The supply of ammunition presented no difficulties.

The light infantry minenwerfers had the same mission as above: they were used either alone or at the same time as the medium minenwerfers.

The supply of ammunition for the 3 small detachments in each infantry regiment is not a simple matter and deserves to be given special attention.

For this reason no more ammunition must be used than is strictly necessary to accomplish the desired mission.

Their use for flat trajectory fire has given full satisfaction.

The medium and light minenwerfers are sufficiently mobile and limber of the medium minenwerfer is very handy.

Good results have been obtained by hooking the light minenwerfer to the ammunition truck. The latter has given complete satisfaction for the transportation of light and medium bombs.

The transport of ammunition has been rendered easy by the dry weather; we have succeeded in transporting in a two horse wagon 10 medium or 90 light bombs, and with a one horse wagon 5 medium or 44 light bombs.

At times the figures given above had to be diminished.

A FIRE CONTROL SYSTEM FOR USE WITH MOBILE SEACOAST ARTILLERY.

By Colonel Meade Wildrick, C. A.

Due to the types of heavy mobile artillery designed for our future Coast Defense System it becomes necessary to evolve a satisfactory fire control system to be used with these new weapons. Our present fire control system, due to its lack of mobility, cannot be used with guns that will have to take up positions where no fixed observing stations and telephone lines are installed, and which must be prepared for action simultaneously with putting the guns in position. Therefore the new fire control system must meet the following requirements:

(a) It must be possible to install the system at any point along our seacoast in one or two hours time.

(b) It must be possible to send firing data to the guns by the time the guns are in position and ready for action.

(c) It must be capable of replacing our present fixed fire control system for our permanent armament when this fixed fire control system is put out of commission.

It is believed the fire control system here outlined will fulfill all the above requirements. Fortunately the topographical methods as developed in France and taught at the Coast Artillery School during the past year fit in nicely in this proposed system with our old fire control instruments, such as the Plotting Board (modified), Deflection Board, Pratt Range Correction Board, etc., and give us the solution to the problem as outlined above.

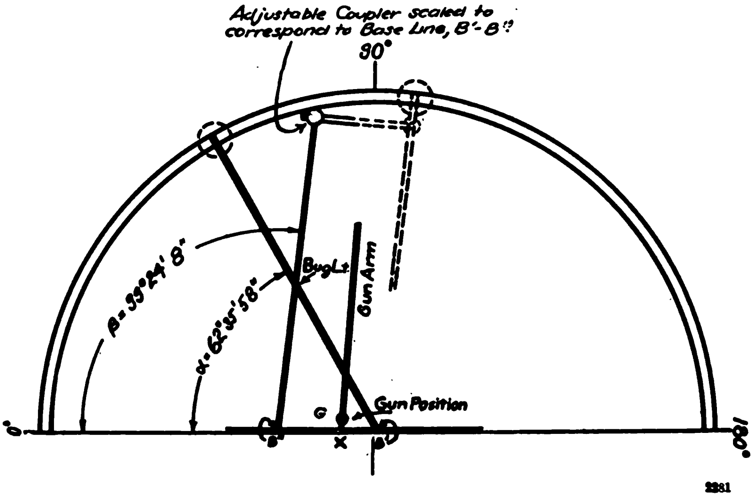
To illustrate the propsed system let us first briefly describe its component parts and then assume a hypothetical problem to show the manner in which it functions.

FIRING MAP

The basis of the whole system is an accurate map upon which is superimposed a quadrillage. This map is used for the purpose of locating base-end stations, gun positions, datum points, etc., and for determining therefrom data with which to orient azimuth instruments, plotting boards, azimuth circles and sights. In other words a map similar to the French "Planchette de Tir," with which we are all familiar. Steps should be taken at once to prepare such a map to cover all our coastal and strategic areas. This map should be prepared by the Corps of Engineers, who have the facilities and necessary equipment for its proper execution.

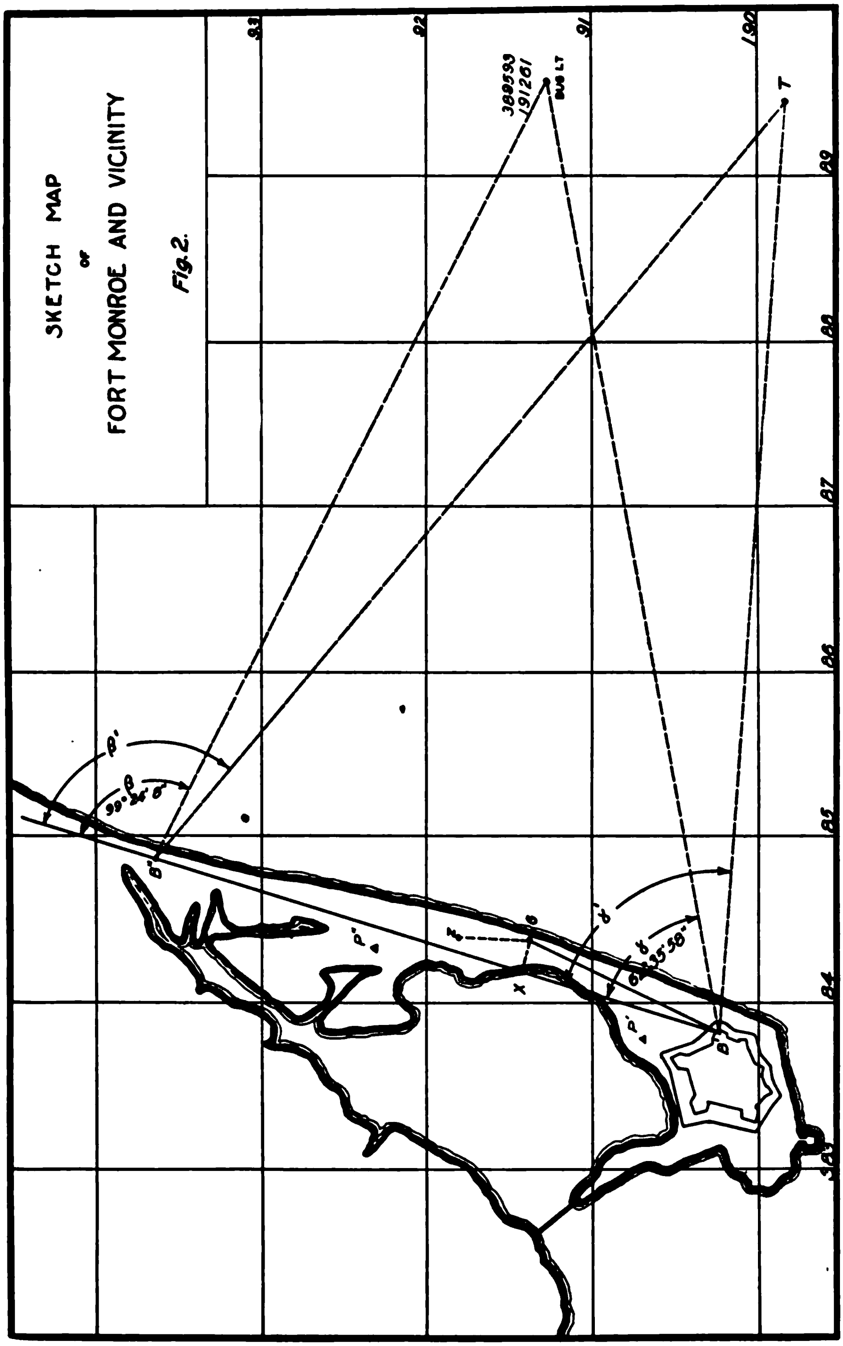
THE PLOTTING BOARD

The plotting board to be used with this system is similar to our present board except that the base line arm is fixed and the graduations on the azimuth circles for both the primary and secondary arms are the same and are also fixed, running clockwise from 0° - 180°. This has the great advantage over our old board of not having to orient the base line arm and of making the plotting board a universal board. See Fig. 1.



SKETCH OF PROPOSED UNIVERSAL PLOTTING BOARD
Fig. 1.

The gun arm azimuth circle is also fixed and is graduated from 0° - 180°. There is an adjustable coupler which is scaled to correspond to the base line scale and which can be set to the length of the base line by means of a locking vernier. In other words the proposed board is exactly similar to our present board with the above exceptions and due to its simplicity, it



SKETCH MAP
of
FORT MONROE AND VICINITY

Fig. 2.

would seem superior to other types of universal plotting boards.

The rest of the fire control apparatus would be same as at present with the exception that the Tide Curve on the Pratt Range Correction Board would be replaced by an Elevation Curve, and would correct for the difference in level between the heights of the gun and actual water level (not mean low tide). A T.I. bell can be connected up on our Telephone Circuits.

OPERATION OF SYSTEM

To illustrate the manner in which the proposed system would operate let us assume the following hypothetical problem.

You are in command of a battery of Railroad Guns, or Tractor Guns transported on flat cars, and have been ordered from the Coast Defenses of Savannah to reenforce the mobile and permanent armament at Fort Monroe. Assume you arrive at Fort Monroe over the Chesapeake and Ohio Railroad at 7:00 A. M. Upon arrival you are ordered by your Group or Battalion Commander to put your battery in position at G immediately. See Fig. 2. You are told to locate your own base end stations.

You call your Orienteur Officer and tell him to locate the B′ and B″ stations as indicated in Fig. 2. You then notify your telephone details to lay the necessary lines from the base end stations, as located by the orienteur details, to the gun position at G, and to connect you up to the proper fire command.

The orienteur details then determine the co-ordinates of B′, B″ and G by the ordinary tepographical methods. To facilitate the location of base end stations, gun positions, etc., triangulative points such as P′, P″, Fig. 2, should be suitably marked and their position and co-ordinates printed directly on the map. The co-ordinates of some Datum Point such as Bug Light should also be printed directly on the map and can be obtained therefrom.

Let us assume the co-ordinates as determined by the orienteur details to be as follows:

Point	X	Y
B′	383831	190231
B″	384885	193625
Gun	384380	191365
Bug Lt.	389593	191261 (from Map)

We then have all the data necessary for computing the length and Y-Azimuth of the following lines:

(a) B′ - B″ Length = 3553 m.
Y-Az. = 17° 15′ 8″

(b) B′ - Bug Lt., Length = 5854 m.
Y-Az. = 79° 51′ 6″

(c) B″ - Bug Lt., Length = 5270
Y-Az. = 116° 39′ 16″

(d) B′ - Gun, Length = 1260 m.
Y-Az. = 25° 49′ 58″

Having computed the above data we can now orient the azimuth instruments at B′ and B″ and also the plotting board.

ORIENTING THE AZIMUTH INSTRUMENTS AT B′ AND B″

As the graduations on the plotting Board run clockwise from 0° to 180° for both the primary and secondary arms we must orient the azimuth instruments at B′ and B″ to correspond with these graduatons. In other words the azimuth of the base line is always considered as 0° and the angles of intersection on any datum point or target are measured in a clockwise direction from the base line as a basis. Thus in Fig 2. the plotting board azimuth of Bug Light as measured from B′ station is the angle α and is equal to the difference in Y-azimuth of the lines B′ B″ and B′ - Bug Light. Similarly the plotting board azimuth of Bug Light from B″ station is the angle β or the difference in Y-azimuth of the lines B′ B″ and B″ - Bug Light. Now set off the angle α on the azimuth instrument at B′ and bring the instrument on Bug Light. Similarly set off the angle β on the azimuth instrument at B″ and bring this instrument on Bug Light. Both instruments are then oriented to measure angles in a clockwise direction from the base line B′ B″ and correspond to the graduations on the azimuth circle of the plotting board for the primary and secondary arms. See Figs. 1 and 2.

ORIENTING THE PLOTTING BOARD

Having computed the length and Y-azimuth of the line B′ G we can solve trigonometrically the right angle triangle B′ G X, as we know the length of the hypotenuse B′ G and the angle G B′ X, (The difference in Y-azimuth of the lines B′ B″ and B′ G.) Solving we obtain the following:

B′X (Left on Base Line)	1246 m.
XC (Front on Base Line)	188 m.

With this data we can set the gun arm center over the directive point G of the battery and the plotting board is oriented.

COMPUTING FIRING DATA

We are now ready to track any target in the field of fire. Assume in Fig. 2 a target T. We can measure on the azimuth instrument at B′ the angle α' and set it off on the primary arm of the plotting board. Similarly we can measure on the azimuth instrument at B″ the angle of β' and set it off on the secondary arm. The intersection of the primary and secondary arms will then locate the position of the target on the plotting board. In this way we can obtain as at present the range to the predicted and set-forward points and make the necessary ballistic corrections on the Pratt Range Correction Board.

When using indirect fire another point as Z can be located. The Y-azimuth of the line ZG can then be computed. Set off the difference in Y-azimuth of the line ZG and B′B″ on the panoramic sight or Azimuth circle of the gun and the battery can be fired using Case III.

CONCLUSIONS

From the above discussion it is apparent that the methods of fire control for our heavy artillery can be made practically identical, whether firing at a moving target, such as a ship, or at a stationary land target. The orienteur methods and ballistic corrections are the same, the only difference being that when firing at a moving target a plotting board must be used to obtain the range and Y-azimuth of the set-forward point.

By making the modifications to an old Whistler-Hearn Plotting Board as indicated in Fig. 3 and using it in conjunction with a properly prepared map of the Coast Defenses, it is believed that it would be possible to try out this proposed system in the various Coast Defenses while conducting Subcaliber and Service target practice with either permanent or mobile armament during the present year. In this way we can prove by practical demonstration the following important points:

(a) That we can fire our old fixed armament using a mobile and elastic fire control system similar to that described above.

(b) That we can fire properly mounted mobile armament, as accurately as fixed armament against moving targets, such as hostile warships; and that the same method of fire control can be employed for both types of armament.

UNIVERSAL PLOTTING BOARD

Similar to Whistler-Hearn Board
except as Noted below.

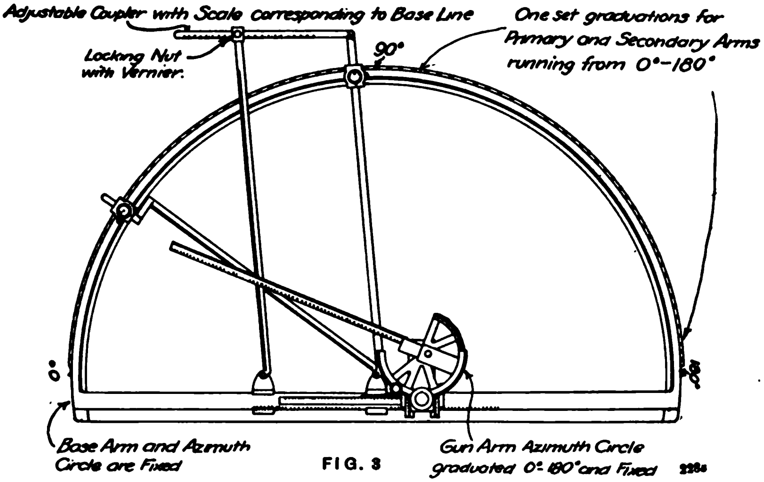

Adjustable Coupler with Scale corresponding to Base Line
Locking Nut with Vernier.
90°
One set graduations for Primary and Secondary Arms running from 0°–180°
0°
180°
Base Arm and Azimuth Circle are Fixed
Gun Arm Azimuth Circle graduated 0°-180° and Fixed
2284

FIG. 3

(c) That the methods of Fire Control used by our Coast Artillery Troops in France when firing at fixed land targets are practically identical to the proposed Seacoast Fire Control Method described above for firing at moving targets.

NOTES ON THE DEVELOPMENT OF ARTILLERY FOR THE FUTURE.

By Major Augustus Norton, C. A.

The events of the Great European War all tend to confirm a great General's observation that "Artillery conquers and Infantry occupies." Whereas the American Artillery did not have the opportunity, for lack of time, to attain the high degree of efficiency that was constantly sought, it nevertheless proved to be most effective. Therefore, in order that, in future wars, the artillery may continue to retain its enviable position every possible effort must be made to formulate and put into effect, at once, a safe and sound policy, which will be a guide for the future in organizing, training, and equipping the American Artillery.

The following remarks attempt to set forth briefly some of the more important conditions that have developed during the period of active participation on the part of the United States in the world war. There is coupled with the majority of the conditions enumerated a short critism intended to be corrective, rather than derogatory.

For the purposes of convenience the entire subject will be divided into the following parts:

I. Administrative and Executive Control.
II. Composition of the Artillery.
III. Personnel and Training.
IV. Guns and Materiel in General

I.

The organization of General Headquarters, A. E. F., provided for a Chief of Artillery, whose function it was to keep the Commander-in-Chief advised on all artillery matters, other than tactical. This Chief developed the artillery policy and his sphere of activity embraced all matters concerning the actual final "production" of artillery units for service at the front. He directed the organization, training, and equipping of all such organizations to include trench and anti-aricraft artillery. As many matters are common to all artillery it was possible to co-ordinate all training and supply of equipment under a single Chief, thereby making it possible to adhere to one policy and approach standardization. The staff of the Chief of Artillery must naturally be so composed as to place trained officers in charge of the various sections. This single organization is clearly an advantage over four separate but smaller organizations; one for heavy artillery, one for light, one for trench artillery, and finally one for anti-aircraft. The question of motorization, the matter of equipment and matériel in general require the services of the largest section in any artillery chief's office. If this most important branch had not been handled under one chief for all classes of artillery, greater delays, duplication of work, and multiplicity of types would have resulted. The entire plan employed resulted in unity of control and met with indisputable success in every phase of the work.

II

The composition of the American Artillery, A.E.F., respective to classification, general types and amounts, seems to have been well-determined in advance. So far as the types, accepted as standard in the approved program, have been tested in actual warfare there has been but little criticism offered. Classification as originally determined appears to have been correct and the amount of artillery needed requires but small additions.

The following outline is believed to represent what should be termed the standard classification:

(a) Railway Artillery Reserve;

Pertains to an army or group of armies and should be composed of large caliber howitzers, ((12-inch to 16-inch) and high-powered long range guns (8-inch to 14-inch).

(b) Army Artillery;

Pertains normally to an army and should be composed of highly mobile intermediate caliber howitzers (8-inch and 9.2-inch) and high-powered long range guns (5-inch to 7-inch).

(c) Corps Artillery;

Pertains to an army corps and should be composed of highly mobile intermediate caliber guns (4.7-inch to 6-inch) and large caliber trench mortars.

(d) Divisional Artillery;

Pertains to a division and should be composed of highly mobile small caliber howitzers (6-inch) and high-powered guns (3-inch) and intermediate and small caliber trench mortars.

(e) Anti-Aircraft Artillery;

One element to pertain to the rear areas and the other to an army; should be composed as follows:

1. Semi-fixed for defense of rear areas, guns (3-inch) and searchlights.
2. Mobile for operation in the zone of the army, guns (3-inch) and machine guns, and searchlights.

The amounts of the different classes of artillery required for normal operations appears to be about as follows:

(a) R.A.R. Two brigades per army—(144 guns).

(b) Army Artillery. Four brigades of guns (288) and four brigades of howitzers (288) per army.

(c) Corps Artillery. One brigade of guns (48) and one trench mortar battalion (24), per army corps.

(d) Divisional Artillery. One brigade of guns (48) and howitzers (24) and one battery of trench mortars (12) light, per division.

(e) Anti-Aircraft Artillery.

1. Semi-fixed; amount dependent upon situation, usually one sector (8 guns) per location is the average. Twenty-four sectors (192 guns) should be held ready. Three platoons of searchlights (9) is the average per location.
2. Mobile; eight sectors of guns 3-inch (64), five machine gun battalions (240) and ten searchlight companies (150) per normal army front.

(Amount determined as follows; one gun, one group of four machine guns and one searchlight per kilometer of front. Searchlights to be arranged in three bands.

III

Prior to our active combatant participation in the recent war, the personnel of the American Artilley was almost wholly dependent upon the advice and experiences of our allies for information as to the rôle played by the artillery in the great struggle and the manner of playing it. As a most natural result of this conditon, we developed practices which were too largely applicable to stabilized warfare; therefore, the conditions to be encountered in purely open operations were, to some extent, overlooked in the sense that they were overshadowed by the demands and principles resulting from the type of warfare that had predominated.

Artillery units arriving in France were in general well versed in the groundwork, but as a rule practical knowledge and experience were lacking. Due to the fact that the personnel in France available as instructors were also deficient in this respect the normal type of instructor bordered all too freely on the theoretical. This condition was remedied however as soon as circumstances permitted.

It was necessary in a great many cases to detach temporarily a large percentage of the personnel of incoming organizations and send them to various instructional centers. This, of course, was undesirable. In fact some organizations went to the front with a personnel that had not been assembled as a unit, but for a very short time. This made the problem of organization difficult for the regimental commanders. It now appears that it is desirable to train regiments as a unit and thereby permit the organization machinery to be perfected by actually performing its functions through the training period.

Every effort must be made to perfect the methods of peace time training. This development must be organized on a sound basis, the proportion of theoretical to practical work must be carefully determined, and the final seasoning—the finishing touches of the training—must contain a large element of reality.

In the future, therefore, we should take into consideration all conditions of warfare, and our system of training must be so outlined as to make prime note of this provision. The training must be thorough; it must develop artillerymen of the highest type. The preliminary work and that which follows should always demand extreme accuracy and follow the standard practice. When the artilleryman has definitely acquired this, the time has arrived to allow him to develop resourcefulness, and this can best be done by requiring him to operate under conditions which range from the ideal to the most primitive. The purpose to be accomplished would be the development of a type of artilleryman how sought accuracy at all times, but who would be able to exercise proper judgement in reducing the degree of accuracy when the circumstances permitted or required it. In brief, the technique must always appear, whereas the execution of the work will be only in such detail as the implements at hand will permit.

For the Americans this has been a war of expedients, our resourcefulness was a determining factor in the success of our operations and it would be a great mistake not to foster this characteristic trait of the average American seeking to become an artilleryman and develop it along lines which will serve the purpose in mind.

It is believed that the experience gained by our artilleryman in actual warfare has now been sufficient to furnish us with the necessary material and knowledge to formulate and put into effect a thorough and proper scheme of training.

The result of observation leads to the belief that certain subjects were not sufficiently emphasized during the training of many artillery units. These are discussed briefly in the following paragraphs.

Great stress must be laid on liaison and its maintenance under all conditions. The establishment and maintenance of communications is extremely difficult at times, but every artilleryman should be impressed with its importance and made to realize that it is an integral part of every artillery maneuver. Unless a battery can receive firing orders and have knowledge of the location of the infantry lines it must remain idle. An organization may excel in the art of maneuvering and going into position and in the execution of fire, but unless it has some communication with its tactical chief it is as impotent as a battery without ammunition. Constant liaison with each immediate superior and co-operator is absolutely essential.

Numerous examples to substantiate this can be found in the reports of the offensive operations of the 1st American Army which began on November 1, 1918. The infantry advance was so rapid that the artillery was put to test even to maintain the pace. Very few heavy artillery units were able to participate between November 2nd and 7th, either because the pace was too rapid or due to the extended line of communications or the utter lack of the same. In fact a large percentage of all the artillery that was actually in a position to fire effectively on the retreating enemy, units that had made heroic physical efforts to maintain the pace, were unable to fire at times because of the lack of proper liaison.

The training of enlisted personnel must be as thorough as that of the commissioned officers. A large proportion of capable and skilled mechanics must be provided for; they must be thoroughly familiar with all motor equipment and gun matériel that they serve. They must be taught to observe rigidly the requirements in regard to upkeep and maintenance. Carefully trained chauffeurs must be provided in large numbers; these men must be better than a mere truck driver. Theoretical work for the enlisted personnel must be reduced to the minimum compatible with requirements and the bulk of the instruction must be practical work and varied as to conditions to the fuller extent.

Camouflage and camouflage discipline hardly existed in our artillery; at least aside from a very few organizations, not even the most rudimentary principles were practiced or observed. This condition either existed as the result of ignorance or because of utter disregard and laziness. It is probable that all three reasons were contributory to the neglect, but fortunately, due to the utter inability of the enemy artillery to be as active as it might have been, the fault did not exact a very heavy toll. It will invariably be found, that where an artillery organization has suffered casualties because of its location having been discovered by the enemy, that its camouflage discipline is better than the organization wherein casualties have not occurred, even though the latter be more experienced from the standpoint of service. The lack of camouflage discipline in one organization endangers those who adjoin it even though the neighboring units are exacting in this respect. The presence of such an undisciplined battery or other unit tends to reduce the standard of those operating in the vicinity and in addition very often nullifies the precautions taken by the latter. It has been stated that "a battery seen is a battery lost"; it is well said. It was the almost invariable practice of the Germans to move immediately a battery when it had once been fired on.

Gas discipline was excellent, as testified by the fact of the number of casualties which were exceedingly small.

Road discipline was poor and almost lacking in many instances. This should be developed and made as exacting as the requirements of close order drills. Important convoys have been delayed for hours because of the utter disregard on the part of some truck drivers of even the simple rules of the road. The formation and drilling of convoys is as important as the training of gun crews. When traveling on heavily congested roads and especially during hours of darkness, it is extremely difficult, even for the most experienced truck trains, to prevent separation and avoid adding to the congestion by forming blockades due to poor or careless driving.

The training of the artillery as a whole was good; it is believed that the heavy and trench artillery units were the best prepared for service at the front. On purely artillery subjects the personnel seemed to be capable. The preparation of firing data and adjustment of fire was well understood, but even greater facility than that displayed should be required. There was a notable lack on the part of many artillery officers to appreciate the value of direct observation of fire; at least, only feeble efforts were made to obtain it. This condition became so serious that the 1st Army Artillery commander was obliged to issue an order requiring the constant search for means of observation.

Due to unavoidable circumstances many artillery units completed their equipment just prior to departure for the front. This was particularly true of transportation. It is believed that this fact was mainly responsible for the lack of road discipline at the front. Without the transportation it was impossible to have practical maneuvers with even an entire battery during the training period. In the future, therefore, this objectionable feature can be overcome if the present production of the necessary equipment is continued until sufficient amounts are actually on hand for all organizations contemplated in the approved project.

As the amount of experience, other things being equal, invariably is a gauge of the efficiency of an organization, the logical conclusion is to secure the experience. This can not be obtained from books, but only through constant practice. Practical work must be indulged in and when an organization is thoroughly schooled in fundamentals it must be required continually to practice and develop its knowledge by means of participation in maneuvers. This is in keeping with the German policy of peace time training. The results obtained by them in war should be a sufficient testimonial to the success of the method.

Practice makes perfect, and that should be the key-note of all future training.

IV

The question of the types of artillery, its equipment and amounts of matériel for the American Artillery was at first largely settled upon advice from our allies. Developments proved that certain changes are desirable, if not necessary.

The question of mobility is undoubtedly the predominant factor in the selection of the proper types of artillery for present-day warfare. Artillery of all types and calibers must be highly mobile and motorized whenever possible. This is imperative in a war of movement, if the maximum amount of artillery is to be kept advancing at the same rate as may be possible for the infantry and also to permit of rapid shifts and concentrations.

The types of intermediate caliber guns and howitzers appear to have been well chosen. The smaller calibers have likewise performed to satisfaction. Our own types of railway artillery, except for the U.S. Navy R.R. unit, had no opportunity of being tested in service. It might be well to indicate at this point that it must be borne in mind that railway artillery that will serve in land warfare will not necessarily meet all the requirements of a coast defense, but the artillery which is suitable for the latter can be used to good advantage for the former state. The success of mortorized light field gun units would indicate that it is advisable to adopt this means of transportation.

All future designs of mobile artillery should take into consideration the necessity of having the following characteristics; long range, long life, wide traverse, a mount and carriage which will permit of rapid travel over roads, either on its own bearings or by means of an accessory vehicle. Even trench mortars should be made more mobile than heretofore. The design of all artillery carriages must further provide for travel over rough and uneven ground and through mud; in fact, it must be able to travel anywhere that a tractor can pull it.

Anti-aircraft artillery of American design or manufacture did not arrive in France in any great quantity. That which was received of the mobile type proved to be unserviceable. As no such American artillery was in operation at the front it was impossible to observe it and form any opinions as to its suitability. The French types, however, were observed and they function well and seem well adapted to the service. They should serve as a guide for our own construction.

Trench artillery of American design or manufacture was not seen in operation at the front. The European types, French and English, can be improved upon to some extent and, with certain small changes, can be taken as models. The main feature to be sought is mobility, and a design which will permit of rapid emplacement. The 150 mm. French T.M. (Model 1917) is a most promising design and can undoubtedly be developed for even larger calibers. Successful changes have been made in the British 6-inch Stokes and the French 240 mm. trench mortars; these improvements pertained to the design of bed plate and method of transportation. A Newton-Stokes mortar has been successfully mounted and fired from a motor truck, but this is not thought to be practical in view of the fact that mortars, due to their very short range, must be emplaced very close to the front lines. Experiments and tests of trench artillery in the American Army are of most recent date, but they have been carried out along most practical and progressive lines.

The equipment manuals as originally published were most liberal as a whole. The quantities required of certain few items were underestimated, but in most instances the reverse was the case and, as a consequence, through lack of transportation facilities and other demands, vast quantities of matériel were actually left behind and thrown along the wayside. Equipment manuals should be carefully revised and in the future they should not be considered as binding, but instead should serve merely as a guide in equipping organizations.

The equipment of artillery units should be divided into two classes, that which is needed and can be used under highly organized conditions, and that which is a minimum to meet the requirements during a war of movement. The first class would contain a complete unit equipment and the second would be made up only of such items of the first class as are absolutely *essential.* The purpose of this division is the same as contemplated when Equipment A, B, and C was inaugurated.

The smallest organization, the battery, should be so equipped that it may function independently when the occasion requires. In some regiments the division of equipment was not properly made to permit this, but as a rule, it could have been done and to good advantage.

There will undoubtedly be great reluctance on the part of some to eliminate the horse where possible, but it must be done in the artillery of the future if the best results are to be obtained. During the last offensive, that of November 1, 1918, horse-drawn organizations were so depleted that in some cases animals were borrowed by one organization from another. In many cases there were only sufficient horses to move the guns, a return trip being necessary to bring up the caissons, whereas tractor-drawn units functioned as usual. Horse-drawn artillery found it difficult to negotiate the roads and frequently requested the services of tractors to assist in passing obstacles.

There are bound to be casualties among animals other than those resulting from shell-fire. A horse requires constant care and attention, likewise the motor, but one motor will do the work of many horses, and, consequently, the personnel required to maintain and operate the latter far exceeds the former. Furthermore, personnel conversant with motors far exceeds in point of numbers that trained in the care of horses.

There is no doubt that the caterpillar tractor has established its superiority for moving all kinds of mobile artillery under any conditions. Many comparisons can be drawn, but the length of this article does not permit of enumeration, besides, it is not thought to be necessary to argue the matter further.

The question of handling fuel for tractors versus forage for horses is so obviously one-sided that it does not need discussion.

Tractors of the Renault type have proved to be invaluable in effecting rapid shifts of artillery from one front to another and for concentrations. This desirable feature will be obtained with the last adopted type of American Truck-Tractor. This vehicle is equipped with a windlass and is so constructed and provided with the necessary parts that it can be used as a truck or a tractor, by merely changing the arrangement of the driving gears and shafts. Trailers must, of course, be provided for shifting caterpillar equipped vehicles when speed is necessary.

It is of the utmost importance to have ammunition trucks of the proper type and design. Frequently it has been necessary to abandon otherwise ideal artillery positions, because of the difficulty of supplying ammunition to the guns or to a point reasonably near the battery. One of the considerations in selecting an artillery position is that of ammunition supply and frequently undesirable sites had to be chosen simply because the type of ammunition truck required it. Therefore, all future designs of trucks for hauling ammunition must take into consideration the necessity for being able to go where the gun can go.

Trucks having a four-wheel steer gave considerable trouble; this feature is, of course, most desirable for a towing vehicle and should be used if possible under those conditions of operation. The truck-tractor previously referred to has an improved design of four-wheel steer when operating as a tractor. Four-wheel drives are without question the best types. The standard size gasoline tank was found to be too small, its size should be increased so as to double the capacity. When running in a convoy motor vehicles must run at a fairly slow speed, frequent stopping and starting is unavoidable, bad roads require the frequent use of the low gears, consequently the consumption of fuel is doubled, sometimes trebled in comparison with the normal consumption under average road conditions and method of travel. Undoubtedly the size of tanks was determined under the latter conditions, but practical experience shows that the increase in size of tanks for all motor vehicles for military use is desirable, if not necessary.

Two general classes of trucks are needed; those for the transportation of ammunition and those for hauling material and supplies. The repair trucks and all other types of special vehicles gave excellent service. They should serve as models for future designs.

As a whole the entire artillery equipment gave excellent service, the principal complaint was shortage. A sufficiently large variety however, was put to test to permit of comparison and warrant intelligent decisions being made as to the best types to be adopted for the future.

Other classes of property used by the artillery received very little criticism. The only article which deserves mention is the Type E-10 radio set. This apparatus gave some trouble.

This design should be perfected so as to eliminate the undesirable features.

Ammunition is an important subject and furnishes a topic for separate discussion; therefore, no attempt will be made to go into the subject beyond a few general remarks.

The latest designs of French projectiles gave uniform results, the destructive effect was good and comparatively few "duds" were reported. The powder was excellent and the form of charge is thought preferable to the American practice; the form of grain and incremental feature is excellent. Percussion primers seem to give fewer failures than the friction type. The French practice of using point fuses almost exclusively is thought to be good. The custom of greasing projectiles is conductive to increasing the life of a gun and reducing dispersion. The use of a tin composition (ordinary tin foil in which fuses are packed serves the purpose) introduced frequently in the powder chamber with a charge almost entirely prevents copper fouling. If copper fouling exists the use of this composition will remove the fouling in a remarkably short time. Guns that have fired over two thousand rounds and that have used the tin foil show very little evidence of copper. The original theoretical life of a 155-G.P.F. gun was placed at about three thousand rounds, but guns of this caliber which had used the tin foil and followed the practice of greasing projectiles were seen in action after firing over eight thousand rounds with no abnormal decrease in muzzle velocity or consequent increase in dispersion.

Since the effectiveness of artillery is largely dependent upon the state and character of its equipment the greatest care and thought must be given to developing all artillery matériel for the future.

The foregoing remarks are most general in nature, but the opinions expressed are based upon the result of careful observation and study. The scope or limited length of these notes does not permit of greater detail, but an attempt has been made to indicate what appears to be a sound and reasonable policy to be adopted in the more important matters pertaining to the development of our artillery for the future.

THE PICKERING POLARIS ATTACHMENT

By 1st Lieut. Roger Sherman Hoar, C. A.

INTRODUCTION

The "Pickering Polaris Attachment" is a simple accessory for an ordinary surveyor's transit. By its means one can determine true north in the field, at any hour of the night, with one setting of the transit, without reference to any books or tables, and without the necessity of knowing either the latitude or the time even approximately. The result will be within the allowable error of precision for orientation for heavy artillery.

The Attachment was evolved as a result of a correspondence between the author of this report and the late Professor Edward C. Pickering, head of the Harvard College Astronomical Observatory. In this, Professor Pickering was assisted by his associate, Professor Willard P. Gerrish.

A working model was made at Harvard and thoroughly tested there. It is now in the possession of the Coast Artillery School, where it has again been tested under the direction of successive Senior Instructors of the Advanced Orientation Course.

The name "Harvard Polaris Attachment" was suggested by Professor Pickering, because the three co-inventors are Harvard men and the first instrument was made and tested at Harvard; but since his recent decease, it has been named in his honor.

DESCRIPTION

North-determination by means of the Pickering Polaris Attachment is purely a field method, no computations or even interpolations being involved. The same setting which gives the azimuth of the reference-line, also gives the latitude, and could be made to give the sidereal time (if that were of any interest to the Artilleryman) simply by graduating the cylinder of the attachment. It bears the same relation to observation of Polaris by the hour-angle method, that the Saegmuller Attachment does to solar observation; except that the Saegmuller Attachment requires a knowledge of the time and latitude and access to an ephemeris, whereas the Pickering Attachment does not.

The Pickering Attachment consists of a tube (similar to the sunshade) which fits over the large end of the telescope of the transit, just tight enough to allow free play. Tangent to a ring around this tube is a straight-edge, with a knob and the letter "P" on one end. In the tube is a pair of prisms which deflect the line of sight from the line of collimation by an angle equal to the mean polar distance of Polaris. The straight-edge and the prisms are so set with relation to each other that, when the straight-edge is lined up with Polaris and β Ursae Minoris (Polaris being at the "P" end) and when the intersection of the cross-wires of the transit is at the same time brought onto Polaris, the telescope will then be pointed at the center of the circle described by Polaris, i.e., the Celestial North Pole.

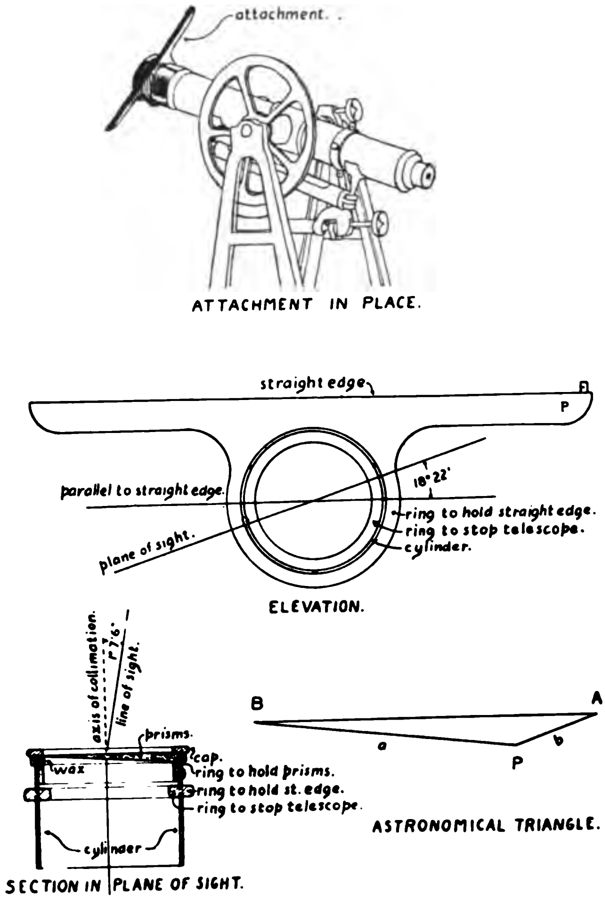
DIRECTIONS FOR USE

Set up on the station and set the plates of the transit at zero with the transit pointing along the orienting-line, whose direction is to be determined. Put on the Attachment. By sighting the telescope and rotating the Attachment, bring the intersection of the cross-wires on Polaris at the same time that the straight-edge is lined up with Polaris and β Ursae Minoris (looking along the outside of the telescope). Remove the Attachment. The line of sight is now pointed due north, and the azimuth of the reference line can be easily read or determined. The angle on the vertical arc is the latitude.

The prisms are not achromatic. The result is that Polaris, instead of appearing as a point of light, appears as a thin spectrum having a length of between $1'$ and $2'$ of arc. As the time of year changes, or as the instrument slightly shifts its adjustment from time to time, different parts of the spectrum can be used, the correct part being ascertained from time to time by trial. It is probable that when the instruments are made in quantities and with great care by instrument-makers, a little color-card can be issued with each Attachment showing the correct part of the spectrum to use each month.

SPECIFICATIONS

The accompanying chart (Fig. 1) shows a perspective drawing of the Attachment in place on the end of a transit, the rear elevation perpendicular to the axis of the cylinder, and a cross-section in the "plane of sight." The Attachment is constructed as follows:



ATTACHMENT IN PLACE.

ELEVATION.

SECTION IN PLANE OF SIGHT.

ASTRONOMICAL TRIANGLE.

PICKERING POLARIS ATTACHMENT.

R.S. HOAR, 1st Lt., C.A.

FIG. 1

2284

A cylindrical brass tube, about 3 cm. long and 1 mm. thick, and of an interior diameter to give a slip fit (like a sunshade) over the end of the telescope (this is 3.7 cm. for most telescopes in use at the Coast Artillery School). About 120° apart on the rear end of the cylinder are three slits about 1.2 cm. long, similar to those on the sunshade of a transit. About 2 cm. from the rear is a flat ring, both inside and out, 3 mm. wide and 3 mm. deep, supporting on the outside a straight-edge about 15 cm. long and 8 mm. deep. The inner ring serves as a stop to prevent the Attachment from going too far onto the telescope. The right-hand end of the straight-edge is marked on the rear face with the letter "P". From the edge of the straight-edge, above the "P", there projects a small knob or pin about 1.5 mm. thick and 3 mm. high.

Inside the front end of the cylinder are a pair of prisms of ordinary spectacle-glass, so set that they will deflect the line of sight from the axis of the cylinder by an angular amount of 1° 7′ 6″, that being taken as the average of the second and third extreme variations in the polar distance of Polaris following the assumed date of adjustment (August, 1919). The "plane of sight," i.e., the plane determined by the line of sight and the refracted line of sight, intersects the P-end of the straight-edge at an angle of 18° 22′, that being taken as a similar average with respect to the value of ∠ A of the Astronomical Triangle. The reason for these averages is explained later herein. The prisms are held in place between an inner ring (secured by three screws driven thru the cylinder) and a cap (screwed onto the front end of the cylinder) any spaces being filled with wax.

All adjustments should be made on the yellow of the spectrum.

PROBLEM OF ADJUSTMENT

But now the serious problem of adjustment presents itself. On account of the nearness of Polaris to the Pole, its right ascension and polar distance are changing rapidly and extensively. β Ursae Minoris is also changing, altho not at such a rate as Polaris.

Let us first consider the changes in polar distance of Polaris. This has one maximum and one minimum in each year. Let us assume that the Attachment is to be adjusted in August, 1919, for a period of two years. During those two years, and part of the next, the polar distance of Polaris will have the following extreme values:

Date		Polar Distance
Jan. 22, 1920	......	1° 6′ 57″
June 28, 1920	......	1° 7′ 30″
Jan. 24, 1921	......	1° 6′ 41″
July 1, 1921	......	1° 7′ 14″
Jan. 27, 1922	......	1° 6′ 25″

(N.B. All star places for 1921 and 1922 are merely estimated, ephemerides not being available.)

The average of the two extremest of these is :1° 7′ 5″. Let us adopt that as the setting for the prisms. We shall then have the following successive extreme variations, with the resulting errors in azimuth (maximum at elongation at 50° latitude):

Date		Var. from Setting		Max. Error in Az.
Jan. 22, 1920	......	− 8″	....	13″
June 28, 1920	......	25″	....	−38″
Jan. 24, 1921	......	−24″	....	38″
July 1, 1921	......	9″	....	−13″
Jan. 27, 1922	......	−40″	....	63″

Thus the Attachment must be readjusted some time between July 1, 1921 and Jan. 27, 1922. From the symmetry of the foregoing table, one will see if the Attachment were readjusted on July 1, 1921, it would thereby then have an error of about −63″, i.e., an error opposite and about equal to that which it would have if left unadjusted until Jan. 27, 1922. Therefore, the correct time to readjust is as nearly as possible midway between July 1, 1921 and Jan. 27, 1922, i.e., about Oct. 4, 1921.

Let us now consider the adjustment of the angle between the straight-edge and the plane of sight. This is based upon the angle A of the Astronomical Triangle. By far the preponderating factor in changes in the size of ∠ A, is changes in the size of ∠ P, which in turn depends upon changes in the right ascensions of Polaris and β Ursae Minoris.

In the Astronomical Triangle of the accompanying chart, P is the Celestial North Pole, A is Polaris and B is β Ursae Minoris. a is the polar distance of β Ursae Minoris, and b is the polar distance of Polaris. P equals the R.A. of Polaris minus the R.A. of β Ursae Minoris. The triangle is solved for ∠ A by means of the following formulas:

$$\tan \tfrac{1}{2}(A+B) = \frac{\cos \tfrac{1}{2}(a-b)\cot \tfrac{1}{2}P}{\cos \tfrac{1}{2}(a+b)}$$

$$\tan \tfrac{1}{2}(A-B) = \frac{\sin \tfrac{1}{2}(a-b)\cot \tfrac{1}{2}P}{\sin \tfrac{1}{2}(a+b)}$$

a and *b* exercise a minor effect on changes in the size of ∠ A, but ∠ A is always the largest when ∠ P is the smallest, and vice versa.

During the two years following August, 1919, ∠ P will have the following extreme values (with which are tabulated the values for *a* and *b* for the same days):

Date	P	*a*	*b*
Oct. 28, 1919	10h 42m 13.72s	15° 30′ 57.42″	1° 7′ 16.61″
Apr. 14, 1920	10h 40m 11.64s	15° 31′ 15.39″	1° 7′ 30.35″
Oct. 29, 1920	10h 42m 49.23s	15° 31′ 10.08″	1° 6′ 59.97″
Apr. 17, 1921	10h 40m 45.77s	15° 31′ 27.39″	1° 7′ 1.00″
Nov. 2, 1921	10h 43m 21.74s	15° 31′ 22.08″	1° 6′ 44.63″

Solving the foregoing formulas with this data, the following values for ∠ A are found:

Date	A
Oct. 28, 1919	18° 11.1′
Apr. 14, 1920	18° 39.8′
Oct. 29, 1920	18° 3.2′
Apr. 17, 1921	18° 32.0′
Nov. 2, 1921	17° 55.8′

The average of the two extremest of these is 18° 21.5′. Let us adopt this as the setting for the straight-edge. We shall then have the following successive extreme variations, with the resulting errors in azimuth (maximum at culmination at 50° latitude):

Date	Var. from Setting	Max. Error in Az.
Oct. 28, 1919	−10.4′	19″
Apr. 14, 1920	18.3′	34″
Oct. 29, 1920	−18.3′	34″
Apr. 17, 1921	10.5′	20″
Nov. 2, 1921	−25.7′	48″

The last is enough error to necessitate readjustment of the straight-edge.

By the same reasoning employed in the case of the prisms, we see that the ideal time to readjust the straight-edge would be midway between April 17, 1921, and Nov. 2, 1921, i.e., July 26, 1921. The ideal date for readjustment of the prisms was Oct. 4, 1921. Some time between these two dates, then, would be the best time to make both adjustments simultaneously. This should be repeated biennially. To get the correct setting for the biennial adjustment take the average of the second and third extremes following the date of adjustment.

One should remember that the foregoing are extreme cases, at extreme times of the year, in extreme latitudes and at extreme parts of the orbit of Polaris. The fact that the two causes of error have their maximum effect one at elongation and one at culmination, and at different times of the year, makes it certain that the combined effect of both will never be as bad as the single effect of one at its worst. At 30° latitude the error is less than ¾ what it is at 50°. The two sources of error are as likely as not to counteract each other. So that the average error is apt to be around 10″, and the extreme error not over 40″. Error can be largely eliminated by an intelligent use of the spectrum, and can be eliminated entirely by averaging the results of two sets of observations taken nearly twelve hours apart.

In view of the just-discussed need of biennial readjustment, it would be well to provide the Attachment with two adjusting screws; but these should be so placed that they cannot be tampered with, except by experts at the times of biennial readjustment.

CONCLUSION

The Pickering Attachment presents the simplest possible method of north-determination. It should be very inexpensive to manufacture. If adjusted biennially, its extreme error will be well within the limits of precision necessary to Heavy Artillery orientation, and its average error in practice will be negligible and easily reducible to zero.

For Field Artillery, the Pickering Attachment is sufficiently precise to become the sole method of astronomical north-determination.

EDITORIAL REVIEWS

Journal of the U. S. Artillery, Past and Future

The JOURNAL was founded in 1892, being evolved from the demands of necessity. In the artillery today there are many whose careers started long since the JOURNAL'S beginning. It is fitting and proper that these new artillerymen should understand how the JOURNAL came to be established, something of its past history, and especially the relation between the JOURNAL and the individuals of the Corps.

Until the late 80's, artillery sentiment was an absent quantity. The artillery was little known at home and not at all abroad. In 1887 there was a meeting of the Artillery Council at Governors Island, which indicated an awakening from a long period of hibernation, and certainly influenced subsequent events. Shortly after this, efforts were made to establish an artillery association. These efforts failed, but nevertheless demonstrated conclusively the need of a medium for the exchange of ideas. As a result, in 1891 a number of artillery officers, believing that a publication should be provided for technical artillery literature, arranged for the quarterly publication of the JOURNAL OF THE U. S. ARTILLERY. This publication was to be devoted strictly to the presentation and discussion of subjects and problems pertaining to artillery, especially Coast Artillery. In this way, due to the wise action of these progressive pioneers, we of the artillery came to possess "a medium of intercommunication under our own control and devoted with an eye single to the interest of our own arm."

In those days there were only five regiments of artillery, containing 288 officers. Now there are over 1200 commissioned officers in the regular Coast Artillery Corps alone. Too much credit cannot be given the handful of artillery officers, and especially the editors of the JOURNAL, who, handicapped by lack of funds, and facing the problem of securing active co-operation and support from an artillery organization lacking in esprit, successfully guided the JOURNAL through its arduous early days. They laid the foundation which insured the permanency of the JOURNAL and developed a magazine which has taken a high position among technical publications at home and abroad. A publication, moreover, which has become an important source of professional information to the Coast Artillery service at large and has enabled the personnel throughout the Coast Artillery to keep posted on current artillery thought and methods. In fact, the present efficiency of our Corps is in no small measure due to the influence of the JOURNAL.

Thirty years ago great problems were in the foreground. These problems have continuously been presented and discussed in the JOURNAL in no uncertain terms, and many of these problems have been successfully solved. There has been a long period of uninterrupted progress in which the JOURNAL has been a medium for bringing order out of chaos. There are now great problems before us: organization and training, new matériel and armament, correction of fire by observation, use of balloons and aircraft in coast defense, and many others, not the least of which is the education of the large number of enlisted specialists and newly commissioned officers in the work of coast artillerymen.

The aim and purpose of the JOURNAL is to publish discussions relative to the problems that are now before us; problems that we *must* solve if we are to take those strides which are indicative of a live, progressive Corps. *Its pages are available for a free and open discussion of all matters affecting the Coast Artillery Corps.* It is only by such discussion that the best results will be obtained and the most searching study of Artillery matters will be possible. To accomplish these results it must not be forgotten that the JOURNAL is now, as in the past, a medium of intercommunication for the *whole* Corps. Neither the School Board, nor the editorial staff, nor any one individual can make the JOURNAL what the Corps wants it to be. This can be obtained only by the active and continuous co-operation and interest of all individuals throughout the service.

Our experienced officers, each and every one, have a duty to perform in assisting in the future development of the Corps and in the education of our new personnel. To you we say, give the Corps the benefit of your experience and ideas. The medium for accomplishing this *is* the JOURNAL.

The younger officers must not only study and learn, but must prepare themselves for guiding the destinies of the Corps in future years. To you we say, "reading maketh a full man, conference a ready, and writing an exact man." Therefore *read*, and when you think you can write, do it, don't wait,— we need your ideas and we want your manuscript.

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Good Counsel

In the JOURNAL OF THE U. S. ARTILLERY for September-October, 1912, there appeared an article giving the history and development of the JOURNAL, written by General John W. Ruckman, U. S. Army. In concluding the article, General Ruckman said as follows:

"Let not the personnel of the Coast Artillery Corps, which has done so well, ever become self-satisfied, for in that condition of mind progress ceases and efficiency dies. The Coast Artillery is no longer a small body of men with unimportant duties incompatible with the object of its being, but a large and efficient corps with well-defined functions and broad fields of opportunity. It has now before it great problems and obligations; small views of administration and instruction will no longer suffice— the methods thereof must be adjusted to big propositions. The Corps is now grappling with problems whose proper solution will affect the history of the world, and narrow-gauge policies will not fill the requirements.

"Work steadfastly to supply the needs of the service. Maintain a broad and generous appreciation of the good work of the other branches, and banish all narrow, petty jealousies that sometimes rise to mar good relations. Efficient officers cannot afford to be narrow.

"Labor always for efficiency and take a loyal pride in high achievement. Work, singly and collectively, to promote teamwork, which alone will secure great results.

"Do not kill off all the 'old' men too rapidly. Young men with energy and advanced ideas are invaluable in any organization, but the old men possess wisdom gained through experience which is indispensable to all successful undertakings. Officers of the latter class are better qualified than the former to discern shoals ahead and avoid them, and by their poise act as a balance-wheel to the pent-up energy of the younger men. These at least are the views of one who has knowledge of both classes, and has had experience in both capacities."

In these days of reorganization, the words of advice quoted above are of even more importance than they were in 1912. It behooves us all to study these remarks carefully and to profit by them.

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Design of Projectiles

The Ordnance Department has recently made some valuable improvements in the design of projectiles. In one instance, a slight alteration of the rotating band increased the range about 30 per cent, and gave a very remarkable decrease in dispersion. A subsequent redesign of the entire shell resulted in the attainment of a range 60 per cent greater than that of the original shell and a reduction in dispersion to less than one-sixth of that obtained with the original shell. Another redesign is being made, from which further gains are expected.

Many factors to which no particular importance has heretofore been attached have been proved to exert a profound influence on the flight of a shell. The whole subject of air-resistance and the retardation of projectiles of various types is undergoing a thorough investigation, and, as a result of many very interesting experiments, it is possible that projectile design will cease to be an empirical subject and may for the first time in history become an exact science. Interesting data is now being collected concerning this subject, so that in the near future it will be possible to publish an article giving reliable information concerning the design of projectiles.

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Coast Defense Armament

The first general board convened in the United States to determine the character of its coast defenses was the "Board on Fortifications or Other Defenses," more generally known as the *Endicott Board*, appointed under an Act of Congress in 1885. This board made a thorough study of the subject and submitted a report in 1886, giving a list of the places to be fortified and the character of the defenses at each place. At the time of this recommendation there were no steel seacoast guns except one 8-inch experimental gun, and there were only a few 12-inch cast-iron mortars. The first 10-inch gun was constructed in 1890, and the first 12-inch gun in 1891. The first disappearing carriage of the modern type was completed for the 8-inch gun in 1893, and for the 10-inch gun in 1894. Although the Endicott report called for certain armored casemates and turrets, no plans had been made for their construction. The report also provided for submarine mines, a limited number of searchlights, and mine defense guns. As a matter of fact, the only part of this proposed system of defense which could be installed was the submarine mine defense. The data upon which the board worked was based on foreign artillery and war vessels of the time, so that it is natural that many changes were later made in the proposed scheme of defense. However, from 1886 to date, the defenses constructed in the United States have followed the general recommendations of this board, being modified with the development of the means of defense. In the meantime, the adoption of the disappearing carriage although not favored by many, as the approved type became a settled policy, and it may also be said that the 12-inch gun was regarded as the type coast defense gun. Between 1885 and 1905 the United States had secured a number of colonial possessions whose defense it was necessary to consider. This, together with an evident necessity of revising the recommendations of the *Endicott Board*, Influenced the President to appoint, in 1905, the "National Coast Defense Board," better known as the *Taft Board*. The purpose of this board was "to recommend the armament, fixed and floating, mobile torpedoes, submarine mines, and all other defensive appliances that may be necessary to complete the harbor defense with the most economical and advantageous expenditure of money."

The list of places recommended for fortification by the *Taft Board* is as follows:

Home Ports

Kenebec River, Me.
Portland, Me.
Southern Entrance to New York Harbor.
Key West, Fla.
Tampa, Fla.

Portsmouth, N. H.
Boston, Mass.
New Bedford, Mass.
Narragansett Bay, R. I.
Eastern Entrance to Long Island Sound.
Eastern Entrance to New York Harbor.
Delaware River.
Baltimore, Md.
Entrance to Chesapeake Bay.
Hampton Roads, Va.
Potomic River.
Cape Fear River.
Charleston, S. C.
Savannah, Ga.
Pensacola, Fla.
Mobile, Ala.
Mississippi River.
Galveston, Tex.
San Diego, Cal.
San Francisco, Cal.
Columbia River.
Puget Sound.
Lake Ports.

DISTANT PORTS

Guantanamo, Cuba.
San Juan, Porto Rico.
Entrances to the Panama Canal.
Pearl Harbor and Honolulu, Hawaii.
Island of Guam.
Manila Bay, P. I.
Subic Bay, P. I.
Kiska Island, Alaska.

Subsequently San Pedro, California, the principal port of the Los Angeles district, was added to the list.

It should be carefully noted that the recommendations of this board were directed toward the accomplishment of *harbor defense.* Some 14-inch guns and one 16-inch gun were recommended for an emplacement. The disappearing carriage was still the approved type, and the entire scheme contemplated the mounting of armament in fixed emplacements.

More recently the *Board of Review* of the War Department has submitted a revised Coast Defense project, which, as approved, provides for the addition of the following armament to the coast defense system of the United States, Panama Canal and Insular Possessions:

26	16-inch rifles
36	12-inch rifles (long range)
23	6-inch rifles
4	3-inch rifles
60	16-inch mortars.

A committee from the Office of the Chief of Coast Artillery is now making a study of this approved project with a view to making it conform to late developments in artillery and to making use of certain matériel now on hand in this country and abroad.

It is believed this committee is being guided by principles which will develop a real Coast Defense System as distinguished from Harbor Defense. Briefly these principles are:

(a) The fundamental consideration that the mount for any large caliber, high power gun should be such as to permit the obtainment of the maximum range of the gun, requires the adoption of the Barbette type of carriage for this class of armament.

(b) It is desirable that a part of the coast defense armament should be mobile so that the adoption of a railroad mount is warranted. The 14-inch, 50 caliber gun may be mounted on a railway carriage and has sufficient power and range to make it an effective coast defense weapon. It is doubtful whether 50 caliber guns of larger caliber than 14-inch can be given railroad mounts.

(c) On islands not connected by rail with the mainland, and other places where mobility is of no importance, the 50 caliber 16-inch gun is considered the best type.

(d) It is believed that the 14-inch projectile will successfully attack any deck protection to be given to battleships. The advantages of limiting the size of the gun to the caliber which will give successful attack are manifest. On this basis the 14-inch howitzer on railroad mount may be accepted as the type coast defense armament of this particular class.

(e) Since the requirements of seacoast defense do not demand the adoption of any particular caliber of intermediate armament, and since considerations of mobility and field service are the deciding factors in this question, the intermediate armament should be secured from mobile artillery provided with suitable ammunition for coast defense purposes. Carriages permitting of rapid traverse may be required; this feature will also be as valuable for field work as for coast defense.

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Test of 12-Inch Gun on Sliding Railway Mount

A test of the 12-inch gun on sliding railway mount for the purpose of determining whether the employment of this type of mount is practicable for coast defense purposes will be conducted at an early date. The tests will be conducted with a view to determining the following:

(a) The normal rate of sustained fire which may be expected with this type of mount.

(b) The system of laying which is best adapted for use with this mount.

(c) Defects of matériel.

(d) Whether there are any minor alterations which can be made which will increase the efficiency of the mount.

(e) Whether any special system of fire control is necessary.

PROFESSIONAL NOTES

The Boat Tail Bullet

By J. R. Bevis, M.Sc., Ph. D.

After months of laborous research and experimenting to prove or disprove my mathematical deductions concerning that shape of the head of a bullet that would give the greatest ballistic efficiency, I proved that the para-ogival, as illustrated here—a cross between the paraboloidal and ogival—a combination of the two was superior in ballistic efficiency to the paraboloidal, the ogival, or the conical.

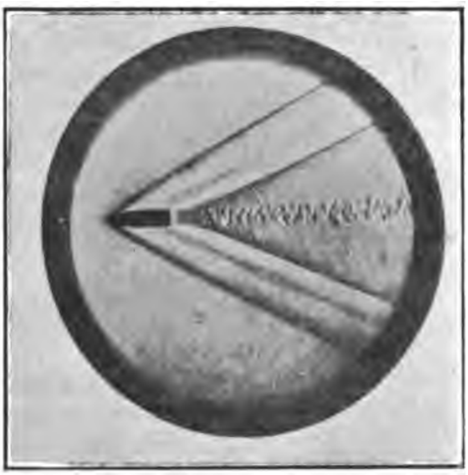


FIG. 1 2286

I do not regret having devoted so much labor to that subject, because I wanted not only a rigorous mathematical but a demonstrable proof of the ballistic qualities of the several shaped heads as well as to have the satisfaction to know that my deductions were correct; not that my deduction may be final, for another shape of head may be evolved that will prove superior to any of these mentioned. But this much is an indisputable fact—the higher degree of ballistic efficiency that any other head that may be evolved can only be modest indeed, for the limit in efficiency is dangerously near. Any further research along that line will hardly be compensated by practical results.

Since the limit of efficiency of the head of a bullet is practically reached and the ballistic coefficient "C" of our rifle bullets is low, research along other lines has likewise brought its reward to a higher degree. So after having devoted many months to the study of the boat tail bullet I give herewith some deductions that may be both interesting and surprising. These deductions are purely mathematical and have not been verified by experiment, but so assured am I that experiment will practically verify these deductions, that I have postponed that part of the work until a more opportune time.

Figure 1 is a photo of a high velocity spitzer bullet in its flight. The photograph shows vividly the bow wave, condensations and rarefactions, the vacuum just behind the bullet, and the trough with eddies of air lying in the wake. A vacuum, if any, offers a force of 15 pounds per square inch of the base of the bullet opposed to its forward translation.

But, is there any proof that a vacuum exists in the wake of a bullet of high velocity? Certainly. Near sea level, air rushes in to fill a vacuum at the rate of 1160 feet per second, and varies with the temperature and pressure and humidity. It is evident that when the forward motion of the bullet is greater than the velocity of the inrushing air a vacuum exists which extends backward in the shape of a truncated cone an approximate distance which equals $\frac{V}{V}$ x radius of the bullet, when "V" is the velocity of the bullet and "v" the velocity of the inrushing air. The length of the vacuum decreases until the velocity of the bullet equals approximately the velocity of the inrushing air when a vacuum is replaced with a high degree of rarefaction.

Another proof, tho indirect, of the existence of a vacuum is—that the value of "n", which denotes the resistance of the air as a power of the velocity (Page 43, B&D, Practical Exterior Ballistics) is greatest when the velocity of the bullet is near 1160 f.s. (970 to 1230 f.s.). This is strong evidence that the law of air resistance is very intimately connected with the velocity of sound and is, therefore, corroborative evidence of an existing vacuum.

To simplify our mathematics I shall use the Newton: Caliber, 30; weight, 150; velocity, 3208; ballistic, coefficient, C; 389; because the value of "n", the power of the velocity is the same both for the muzzle velocity and the remaining velocity at 200 yards, and equals 1.55.

The resistance of the air is calculated by the formula **

$$Rs = \frac{A\ c\ d^2}{g} \times V^n$$

The approximate average velocity over the 200 yard range equals ½ (3208+2707) or 2957 f.s.

$$\begin{aligned}
\log A &= \bar{3}.60905 \\
\log .595 &= \bar{1}.77452 \\
2 \log .304 &= \bar{2}.96574 \\
1.55 \log 2957 &= 5.37982 \\
\hline
&\ 1.72913 \\
\log 32.16 &= 1.50732 \\
\hline
\log Rs &= \ .22181
\end{aligned}$$

Hence, $Rs = 1.667$ ft. lbs.

And the retardation of the bullet is calculated by the formula

$$Rt = \frac{A\ V^n}{C}$$

$$\begin{aligned}
\log A &= \bar{3}.60905 \\
1.55 \log 2957 &= 5.37982 \\
\hline
&\ 2.98887 \\
\log C{-}.389 &= \bar{1}.58995 \\
\hline
\log Rt &= 3.39892
\end{aligned}$$

Hence, $Rt = 2505.6$ f.s.

That is, a resistance of 1.667 ft. lbs. acting thru a space of one second will produce a retardation of 2505.6 f.s. in the velocity of the bullet. But the time of flight over the 200 yard range is only 0.2 second, so the retardation for that time will be 501.12 f.s. which equals exactly the loss in velocity, and this was to be expected.

The resistance of 1.667 lbs. is the combined influence, in this case, of the actual resistance offered by the air upon the head and body of the bullet plus the retarding influence of the vacuum lying in its wake. Since the area of the base of the bullet under consideration is 0.07 sq. in. the influence of the vacuum will equal 1.05 lbs. which subtracted from the actual resistance of 1.667 lbs. leaves 0.617 lbs. the resistance offered by the head and body.

Assuming that there is no opposing force in the wake of the bullet, i.e., neither vacuum or rarefaction, then the retardation that would be produced by the resistance upon the head and body would only equal $\frac{.617}{1.667} \times 501$ f.s. or 185 f.s. as against 501 f.s. over the same range, and the remaining velocity at 200 yards would be 3020 f.s. Then by the formula

$$C = \frac{X}{S(v) - S(V)}$$

Omitting the atmospheric coefficients, we have $C = 1.07$ in striking contrast to its value 0.389.

For the sake of perspicuity I give the following comparative ballistics. R is regular bullet, and B the boat tail bullet having no opposing force in its wake:

	R vel.	B vel.	R time	B time	R ht. of T	B ht. ofT
Muzzle.......	3208	3208	....	....	....	....
200 yds.......	2707	3020	.204	.193	.166	.149
500 yds.......	2049	2746	.586	.506	1.37	1.02
1000 yds......	1223	2325	1.56	1.10	9.73	4.84

If our service bullet were similarly constructed, under the same assumption, the highest point in its 1000 yd. trajectory would be 6.97 ft. as against its present height of 14.5. If these deductions are true, and I see no reason for their not being so, the results obtained by using a boat tail bullet is well worth the strenuous effort and research to evolve the best.

However, the difficulty in bringing out such a bullet will be small as compared with that to be encountered in translating it thru the barrel, if a pointed tail is used, for a boat tail bullet so constructed as to eliminate the vacuum presupposes that the tail come to a point, not unlike C′RF′, Fig. 2.

The French Balle D, a flat base boat tail bullet, CC′ PEF′ F, and some projectiles of our artillery having somewhat similar tails, have proved their superiorty by actual demonstration.

That part of the bullet BC and DF, Fig. 2 which comes in contact with the wall of the bore should end abruptly in order that as the bullet leaves the muzzle the bearings against the wall of the bore will cease at the same instant on all sides, so that the bullet will not be deflected by the longer contact of any one point with the wall of the bore. If the bearing surface of the bullet terminate at CF the offset CC′ or FF′ should be made square with the longitudinal axis, and made as true as it is possible to make it. The shoulder CC′ FF′ forms a gas check also, and by virtue thereof its depth should not vary greatly from the depth of the groove.

If the element of that surface of that head which offers the least resistance is a curve, then the element of the surface of that tail which offers the least resistance to the lateral thrust could not be like that element of the head which offers the least resistance for the reason that the angle of incidence of the lateral thrust upon the tail body is not and cannot be like the angle of incidence upon the head. To state the law generally, that shape of head which offers the least resistance would not offer the least resistance if used in the construction of the tail. Mechanically and mathematically it may be shown that the circumscribing element of the surface of the tail should be a straight line, c′P, Fig. 2.

In Fig. 1 the rarefaction behind the bow wave is evident. The velocity of the inrushing air from a rarefaction to fill a vacuum is in inverse ratio to the degree of rarefaction, which in this case, varies as the altitude, the velocity of the bullet, the shape of its head, etc. If, however, this degree of rarefaction could be determined the problem of evolving the tail for the bullet will have had a good beginning.

We may call the angle Ac′R the critical angle of taper, since the element c′R theoretically is the dividing line between the vacuum and the rarefied air. For the sake of tolerance the efficient angle of taper, Ac′P, must be less than the critical angle of taper, which for the Springfield .30, 150 gr. bullet having 2500 f.s. velocity is approximately 14 degrees. For, if the angle of taper was equal to or greater than the critical angle the purpose desired would be defeated. The fact of which is apparent.

It is not difficult to determine the rarefaction around the body and tail, given the description and velocity of the bullet, and then determine the critical angle taper; but it is a little difficult to determine the maximum value of the angle of taper, or its value when it is most efficient, since its value depends upon the angle of departure and angle of fall, the velocity of the bullet and upon the value of C, into which it, itself, enters. To put it differently, the tail of the boat tail bullet or projectile is determined by the range at which it is desired that the bullet be effectively used. The service .30 cal., 150 gr. bullet is efficient at a range of 1000 yds or less, but it does not meet the requirements in rapid fire guns, or barrage, at 1200 yards or more. A boat tail bullet of the same weight and velocity with the angle of taper constructed for 1200 or 1500 yds. will be much more efficient than the one at present used, but its increase in efficiency may not be sufficient to meet the requirements at those ranges.

When the angle of taper having the maximum efficiency is determined, the length of the tail should be made as long as manipulating and pressure conditions permit, and the longer the better; for the longer, the less the area of its base, and hence the less the opposing force of the vacuum. The opposing force of any base is to the opposing force of the diameter of the bullet, CF, as the squares of their respective diameters. This fact should be borne well in mind when constructing the tail of a bullet.

As stated the total resistance of the air equals the resistance offered by the head and body, plus the opposing force due to rarefaction or vacuity or both. The resistance upon the body is due solely to the lateral thrust of the air.

The trajectory of a bullet is the curve described by the center of gravity of the bullet in its motion thru space. The curve is not a simple one lying in a plane, but the complex resultant of the corrected curve of gravity, the corrected curve of swerve or so-called drift, and the corrected curve for windage —when any. The complexity of the curve may be better seen by giving an illustration. At 1000 yards in a 20 mile, 3 o'clock wind, the Springfield .30-150-2700 rises 14.5 feet corrected for gravity, and corrected for wind goes to the right of the line of sight approximately 114 inches, so that a cavalryman in the line of sight at or near 500 yds. would be wholly missed, the bullet passing approximately several feet over him and about 9 feet to his right.

In no place in its flight does a bullet travel point on, because of its tendency to hold itself obliquely to the line of direction by virtue of its gyroscopic motion. For a bullet in its flight is a gyroscope and obeys the laws of the gyroscope, i.e., it tenaciously resists any effort to destroy the parallelism of its longitudinal axis. However, the parallelism of its longitudinal axis does not remain constant thruout its flight, for when it issues from the muzzle its longitudinal axis is tangent to the curve of its trajectory, but just as soon as it starts on that curve, gravity acting upon the bullet causes the longitudinal axis to deflect from the tangent and therefore inclined from it. Inasmuch as the resistance of the air is always parallel to the tangent at any place in the curve of the trajectory, only as the projectile issues from the muzzle is the resistance equally distributed over the head, that as soon as the longitudinal axis of the bullet is inclined to the tangent, the resistance of the air is oblique and becomes a lateral trust instead of a point thrust. Were it not for this terrific lateral thrust of the air upon the body of the bullet, the longitudinal axis would remain practically parallel to its axis as it issued from the muzzle, excepting the case of swerve.

The lateral thrust due to the corrected gravity curve is on the under side of the projectile or on the convex side of the curve; the lateral thrust due to swerve or the corrected wind curve is on the same of either horizontal side of the projectile.

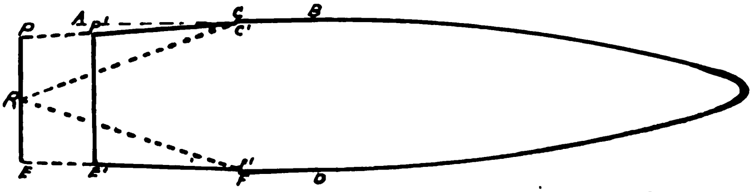
The direct result of constructing a bullet with a boat tail is to lessen the influence of all lateral thrusts of the air, and incidently increase the value of the ballistic coefficient "C". Mechanically, the effect of such construction would be to increase the ascending branch of the trajectory so that the bullet would go "kiting" to a greater extent; and also to increase the length of the descending curve so that the bullet would "coast" in a like proportion, which means a greater range for the same elevation due to lessening of the lateral thrust alone.

I give herewith the formula, which I believe to be new, for calculating the value of C, the ballistic coefficient, of the boat tail bullet,

$$C = \frac{.0001428\,w}{i\,D^2}\left\{1 + \frac{(D')^2 - d^2}{(D')^2} \times \frac{2\tan T,}{\tan Tc}\right\}\text{in which}$$

"w" is the weight in grains, "i" the coefficient of shape or reduction, "D" the efficient diameter, "D′" the diameter at beginning of taper, "d" the diameter of the base, "T" the angle of taper, and "Tc" the critical angle.

Herewith a description of the boat tail bullet illustrated in Fig. 2.



THE BOAT SHAPED PARA OGIVAL BULLET FOR DIRECT FIRE.

FIG 2.

2286

Designed for 1500 yards.

Length of head = .95″
Length of body = .15″
Length of tail = .5″

Length over all = 1.6″
Velocity = 2500 f.s.
Weight = 210 grains
D = .308
D′ = .3
d = .24
i = .4 (experiment may alter this value slightly)
Tan T = .06
Tan Tc = .24
C = .96

The weight could be reduced 10 grains and the value of C would still be .9 plus.

Inasmuch as the Springfield bullet, 150-2700 was not sufficiently effective at the long ranges during this war, I give herewith the comparative ballistics of the Springfield and the above illustrated Para-ogival bullet:

Range	Spr.	Para	Spr.	Para	Spr.	Para.
Yards	Ht.	of T.	Rem.	Vel.	Rem.	Energy
500	2.03′	1.74′	1668 f.s.	2060 f.s.	932 f.p.	1980 f.p.
1000	14.5	9.86	1068	1680	382	1317
1200	25.8	13.5	966	1550	312	1074
1500	52.8	24.2	853	1370	243	876
1800	94.2	40.16	765	1222	196	697
2000	131.7	55.4	713	1144	170	579

It will be noted that the energy of the boat-tail-para-ogival bullet at 1500 yards is greater than that of the Springfield at 600 yards; that at 1800 yards is greater than the Springfield at 700 yards; and at 2000 yards is greater than the Springfield at 1000 yards; that the Springfield in going 500 yards loses 1032 f.s. while the boat tail loses only 440 f.s. These facts are well worth noting. It may be shown also that the boat tail is less susceptible to wind.

An interpretation of the formula as herein given leads us to the conclusion that the tail may be so constructed as to increase the ballistic coefficient as determined by the expression without the braces as much as 100 per cent and possibly more for projectiles for high angle fire.

The interior ballistics of the Para-ogival boat tail bullet would not vary to a great extent from that of the Springfield.

* * *

Recently Adopted System of Projection for U. S. Military Maps

By Captain E. M. Burd, C. A.

Many readers will recall with interest the recently renewed animation shown by the subject of Map Projections, occasioned by the great dependence of artillery work upon the Western Front on accurate maps. For years past the several bureaus of the U. S. Government have been preparing excellent maps of this country, generally using the polyhedral projection; e.g., each sheet being a separate projection upon a tangent plane at the center of the area represented. While these maps are good and sufficient for most purposes, the polyhedron so formed cannot be developed, that is, the sheets cannot be assembled on a plane surface, nor could one continuous grid be superimposed.

To meet these defects in a military sense France developed the well remembered system called Lambert's Projection, whereby the entire extent of the Western Front could be projected upon a cone, the apex of which was on the axis of the Earth extended far beyond the North Pole, and the surface of which intersected the surface of the Earth along the Parallels of

53 and 57 grads North Latitude. This conical surface could be developed into a plane having one continuous grid, and but little distorted, because of the small North and South extent of the area mapped.

A similar projection for the United States was devised and computed, but because of the relatively large area involved it soon became evident that for this country the Lambert Projection had its limitations and undesireable features. The main difficulty was the very appreciable distortion and lack of accuracy along the East and West Coasts, where this quality was most to be desired. Also, near these edges the convergence of the grid system and the meridians was awkward.

The most recent information from Washington gives data for a modified Polyconic Projection by North and South zones, the general outline being as follows. The United States will be divided into seven strips, or zones, each consisting of eight degrees of longitude east and west and the full width of the country north and south. Each strip has its separate projection and grid system, complete and continuous in itself. To facilitate use along the edges of strips, these edges will be extended so as to duplicate the map along the sides of adjacent zones over a distance of perhaps one degree of longitude, each zone showing the grid of the adjacent zone as well as its own grid on this duplicated area, whereby it is thought that military progress from one zone to the next may be followed without delay or inconvenience. By this ingenious arrangement the most exacting requirement, military or otherwise, is satisfied by a convenient and practical system of projection.

On each zone map every parallel of latitude appears as the developed circumference of the base of a right cone tangent to the sphere or spheroid at that parallel. The central meridian of this projection for any zone will appear as a straight line, while all other meridians will appear slightly concave toward it. The parallels for this projection on any map will appear as arcs of circles of different radii, the centers of the arcs being on the central meridian produced beyond the limits of the map. The equator is the only parallel which would be represented as a straight line, and all of the other parallels will be convex toward it. The intersection of the various meridians and parallels for the polyconic projection will differ very little from right angles when the map covers a limited area in the east and west direction, as these zones do. Distances along the central meridian will be true to the scale of the map, as will also be true of distances along the parallels. But diagonal distances and north and south distances will be slightly in error, the amount of the error increasing with the distance from the central meridian. This is unavoidable for it is readily seen that when a section of the earth's surface, which is spherical, is flattened out to the plane of the map, there must be some distortion in the distances given by the map. If the central meridian is held true to scale, as is the case in this polyconic projection, and also the parallels are true to scale, then there must be some distortion as the edges of the map are approached. This will result in a stretching or elongating of the area in a north and south direction, but with an area not greater than ten degrees of longitude in width, the error will be negligible so far as the scale of the map is concerned. For example, at a distance 5° east or west of the central meridian any distance in a north and south direction, as scaled from the map, will differ from the true distance on the earth's surface by only 0.22 of one per cent. This is less than the change in the paper from day to day due to weather conditions, altho the latter is compensated for by using a scale printed on the map.

As previously mentioned each zone has its individual grid system, the Y-axis coincident with the central meridian and the X-axis perpendicular to it at latitude 40° 30′. The zone being narrow, convergence is always small. Tables have been prepared giving the relation between geographical and grid co-ordinates at any point in the zone, and the amount of the convergence. Actual co-ordinates are for convenience increased by 1,000,000 for X and 2,000,000 for Y-values. The maps will be prepared in sheets representing 10,000 yards east and west by 6000 yards north and south, the edges being at even multiples of these dimensions, scale 1 to 10,000. Grid lines will be printed at even thousand yard intervals, and geographical projection lines will be shown at one minute intervals. Each sheet will be designated by the letter of its zone—the zones being lettered A, B, C, etc., beginning at the Atlantic Coast—followed by the first four figures of the X and Y co-ordinates of its southwest corner. Thus A 1160.2292 indicates the sheet of A zone having co-ordinates X = 1,160,000., Y = 2,292,000 at its southwest corner. Each sheet will also be given a distinct name, like the quadrangle sheets of the Geological Survey maps.

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NOTICE

BOOK REVIEWS and INDEX TO CURRENT MILITARY LITERATURE omitted in this number will be published in the May number.

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—1919—

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JOURNAL UNITED STATES ARTILLERY

PRIZE ESSAY COMPETITION

1918

The JOURNAL U. S. ARTILLERY announces the following for its annual competition.

PRIZES

One hundred and fifty dollars will be given for the best essay and one hundred dollars for the second best essay submitted on any Coast or Heavy Artillery subjects.

CONDITIONS OF THE COMPETITION

(a) Competition will be open to all readers of the JOURNAL.

(b) Award will be made by a committee of award, consisting of three persons, to be nominated by the Coast Artillery School Board. If no essay submitted seems to the committee worthy of a prize, none will be awarded. Honorable mention may be made of any essay submitted which seems to the committee worthy thereof, but to which a prize is not awarded.

(c) All essays entered in competition will become the property of the JOURNAL OF THE UNITED STATES ARTILLERY. These will be published, if approved by the Coast Artillery School Board.

(d) Copy must be typewritten, with lines double spaced, on one side of the paper only, and must be submitted in triplicate. If illustrations are included, one of the three copies thereof must be in the form of drawings, tracings, or photographs (not blue-prints nor brown-prints).

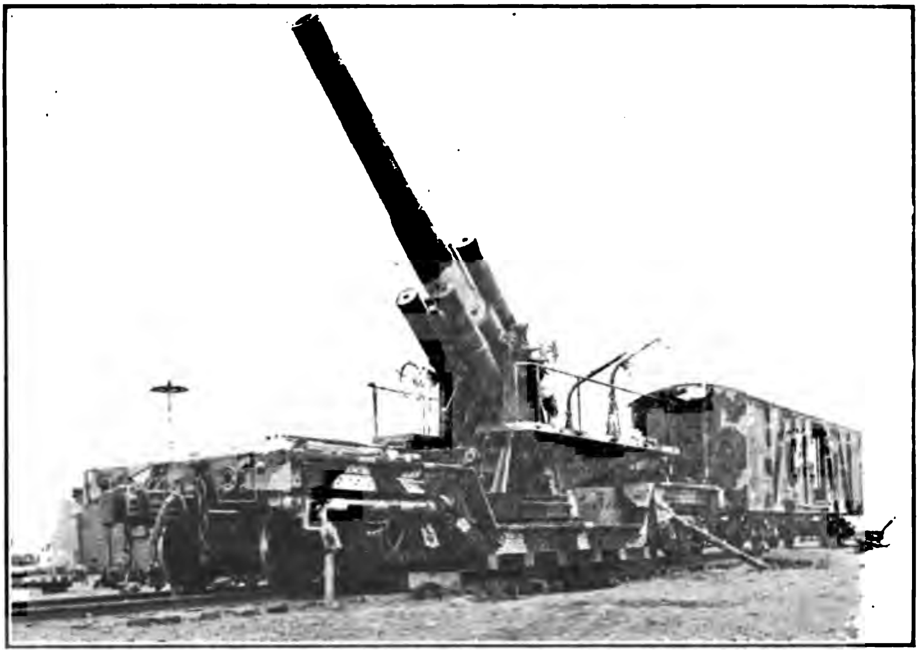
(e) Copy must contain nothing to indicate its authorship, must be signed with a *nom de plume*, and must be accompanied by a sealed envelope containing this *nom de plume* and the name of the writer. This envelope will remain in the hands of the Editor of the JOURNAL and, after award has been made by the Committee, will be opened in the presence of the Coast Artillery School Board.

(f) Copy must be received on, or before, December 31, 1919. It must be addressed JOURNAL U. S. ARTILLERY ana the envelope must bear the notation, "Essay Competition."

NOTICE

The JOURNAL U. S. ARTILLERY desires to receive from its readers, titles of subjects which they consider would be of interest to the service.

Frontispiece



2287

THE PRIDE OF THREE ARMIES

HUGE AMERICAN RAILWAY ARTILLERY OF 16-INCH CALIBER. PRODUCED BY THE ORDNANCE DEPARTMENT, U. S. ARMY. CAN BE PUT INTO POSITION IN 15 MINUTES ALONG ANY PIECE OF TRACK. WILL FIRE ALL AROUND HORIZON. IN REAR IS SEEN THE AMMUNITION CAR, WHERE SHELL AND POWDER ARE KEPT. RAILWAY ARTILLERY IN FRANCE IS MANNED BY U. S. COAST ARTILLERY.

JOURNAL

OF THE

UNITED STATES ARTILLERY

VOL. 50, No. 3. MAY, 1919 WHOLE No. 153

A System of Camouflage for Railway Mounts

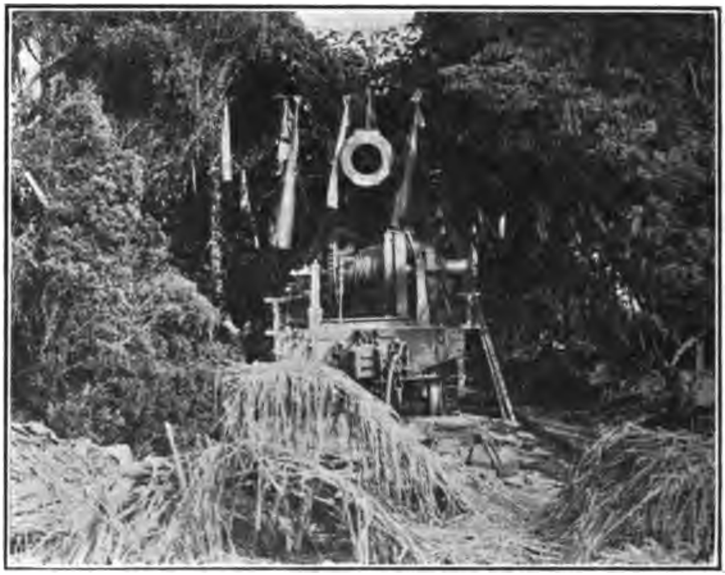
By John M. Goodwin, Camoufleur Ordnance Department,
United States Army

The introduction of the aeroplane into modern warfare has radically changed the problem of concealment of Heavy Artillery. The Disappearing Gun and the hidden battery are no longer protected from the range finding devices of an enemy. Hand in hand with the devices in range finding introduced by aerial observation and sound ranging, there comes the counter protection—camouflage.

The term camouflage includes every method of deceptive concealment and the war camoufleur must be versed in the tactical employment of Artillery, in the Art and Science of Color, and in the chemistry of pigments. He must understand every vantage point of high altitude observations, and the effects produced by the use of the ray filter and the exaggerated stereoscopic effect. He must know how to disperse the shadow silhouette and how to conceal even foot prints in the grass, which through the telescopic camera can be readily detected even from a distance as great as four miles in the air.

The camoufleur must study each problem before him and solve it by the application of scientific principles and common sense.

There are two distinct types of camouflage, each adapted to meet its own practical requirement. These systems are briefly: The Five Color System and the Three Color System. The Five Color System which has recently been approved, meets the several requirements for concealment of Heavy Railway Mounts in which the great mass of solid surface must be broken up into several separate masses, and the shadow cast by the mount must be hidden as well. The introduction of the two new colors, "Mauve" and its complement, and the separating of the opaque and transparent pigments by an atmospheric color effect, produce the novel results obtained.

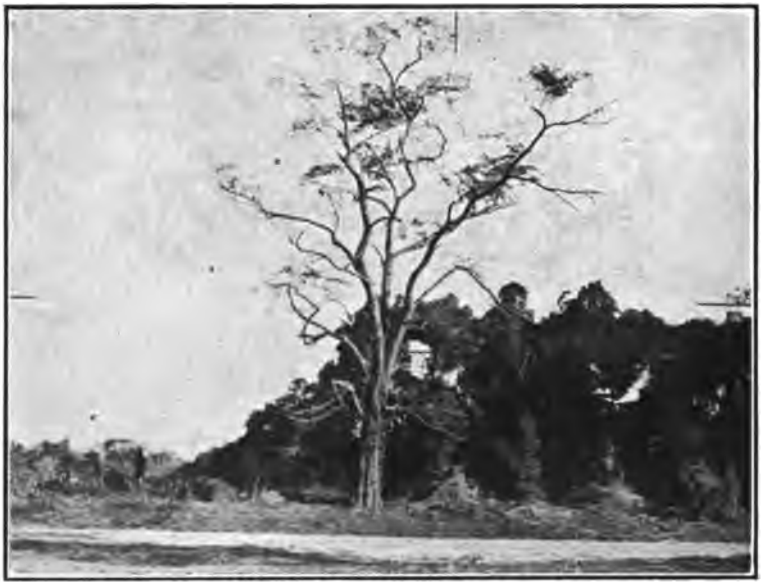


A 2288

16-INCH HOWITZER ON RAILWAY MOUNT, CONCEALED UNDER CAMOUFLAGE CANOPY. TRACK IN FOREGROUND CAMOUFLAGED BY WOVEN BULRUSH ON CHICKEN WIRE, SPREAD OVER THE TRACK IN SHORT LENGTHS SPANNING THE ROADBED, AND EASILY ROLLED OFF TO ONE SIDE, TO ALLOW THE SUPPLIES TO BE RUN IN AT NIGHT

B 2289

OPENINGS IN ROOF OF CAMOUFLAGE CANOPY AS SEEN FROM INSIDE THE CANOPY



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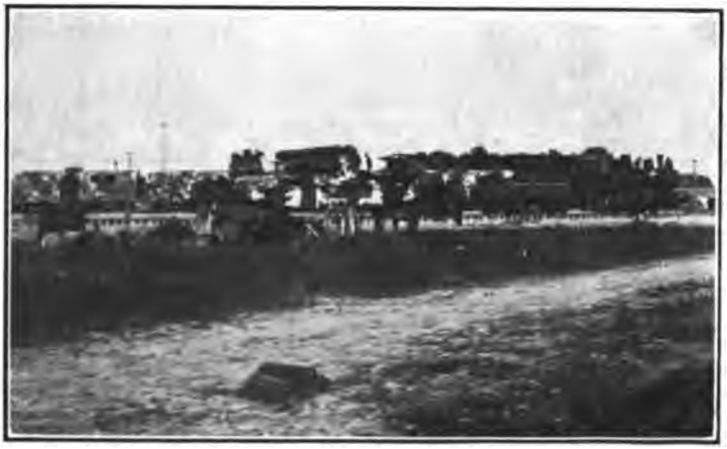
2390

EXTERIOR VIEW OF CAMOUFLAGE CANOPY SHOWING ALL THAT IS VISIBLE OF THE MUZZLE OF THE 16-INCH HOWITZER:---THAT IS THE OUTLINE OF THE GREEN "FIN" SECURED TO THE GUN MUZZLE AT HIGH ELEVATION.



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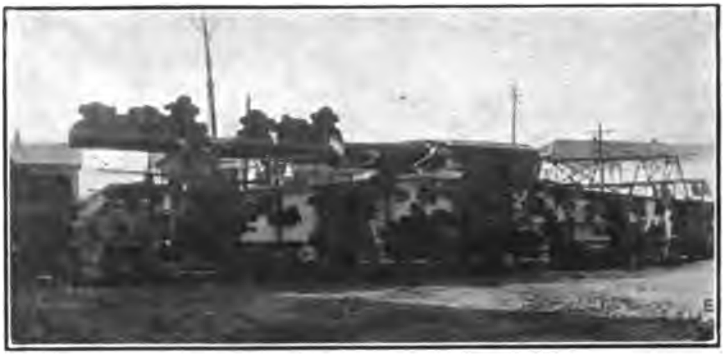
2291

16-INCH HOWITZER ON RAILWAY MOUNT, SHOWING HOW THE CAMOUFLAGE PAINT AND "FIN" BREAK THE OUTLINE AND CONCEAL THE FORM

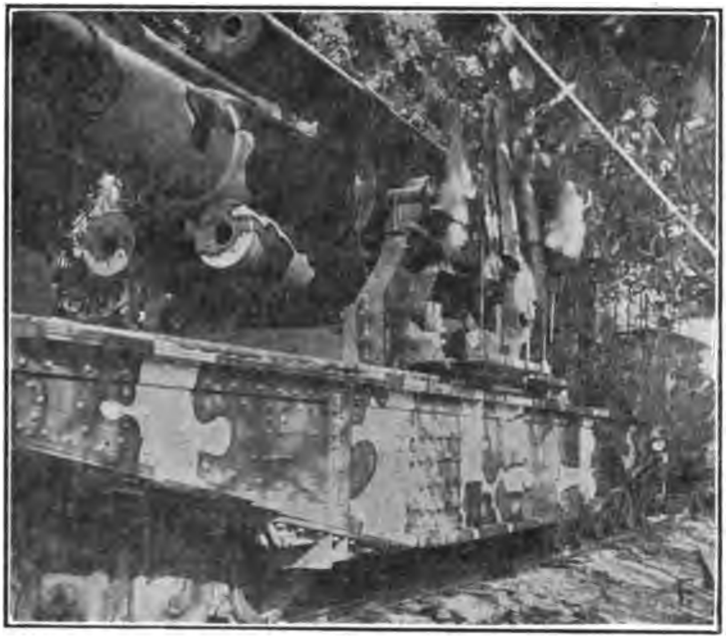
The Three Color System in connection with the field gun presents very small surface areas for protection and casts no definite shadow. The method of treating this problem has consisted principally in an endeavor to hide the field piece by blending its form and shadow with the landscape. In order to accomplish this blending only three colors are used—green, yellow, and cream. These colors are used in small, irregular shaped patches separated by heavy black masses also of irregular shape. The results of the method as applied to the field gun have proved very satisfactory in protecting it from observation. The blending of the comparatively small patches of alternating green, yellow, and cream, gives an even tone that does not attract the eye. This same method, however, when attempted on the railway mount with its large flat surfaces makes it more conspicuous than if it had been painted the usual Olive Drab Color.



12-INCH RIFLE ON SLIDING RAILWAY MOUNT, SHOWING THE FOLIAGE SILHOUETTE ON THE GUN MUZZLE, FORMED BY THE ATTACHED "FINS"

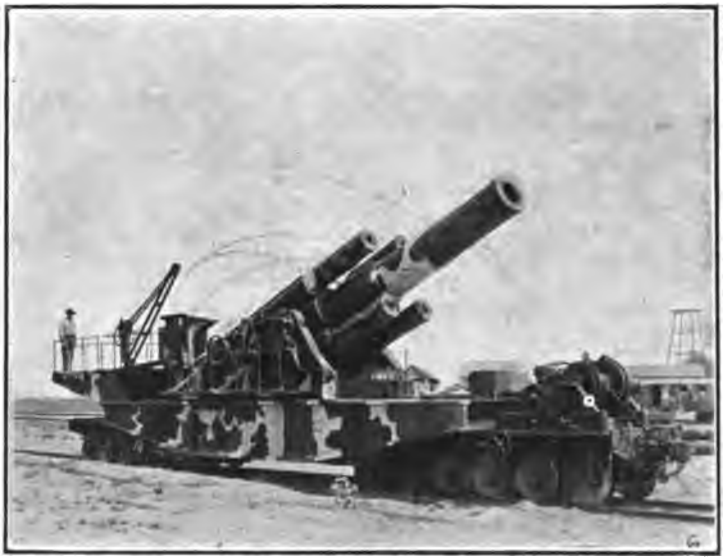
In the problem of ship camouflage the question is more of distorting perspective than blending colors. The object here is to "Camouflage" the *course* of the vessel and to render its direction uncertain. Black-White, and color contrasts give distorted forms.

The introduction of the large caliber guns on railway mounts has introduced several new conditions, which conconditions in turn make a new system of camouflage imperative. The extensive experiments in England in the early part of 1917 resulted in suggestions to obviate defects proved to exist in the then employed methods of camouflage for the railway mount. In developing the five color system of camouflage in the United States the lines of these suggestions have been modified and extended by numerous experiments conducted at the Proving Ground by the Ordnance Department. The theories employed have been inspected and corrected by flights at various altitudes, and by the comparison of aeroplane photographs taken simultaneously with the optical observations of different observers at the Proving Ground. Further careful study of the required conditions by those who have made observations both at home and in France have verified the experiments of the Ordnance Department.



16-inch Howitzer on Railway Mount, under canopy, showing the light and shadow effect of the camouflage in combination with real sunlight and shadow

Following the lines of discovered faults in the previous methods adopted to conceal railway mounts, there has been a concerted effort made by the Ordnance Department to bring together the constructive criticisms of the scientific camera expert and the experimental work of the camoufleur, in order that the opposed branches may work in unison for the common cause. The purpose of the scientific camera expert should be to discover flaws in the work of the camoufleur, and the



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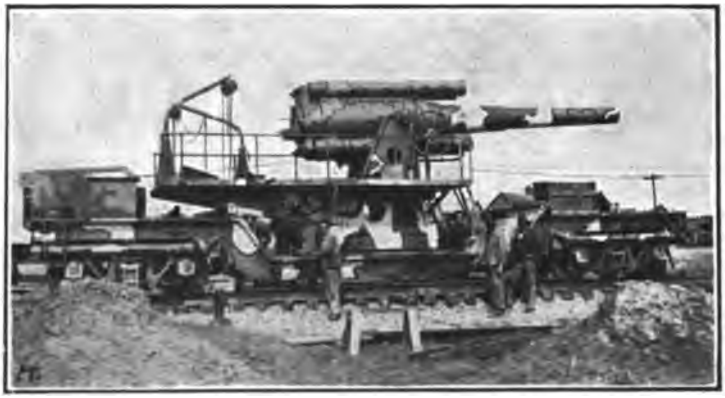
16-inch Howitzer on Railway Mount. Near effect of camouflage in the open



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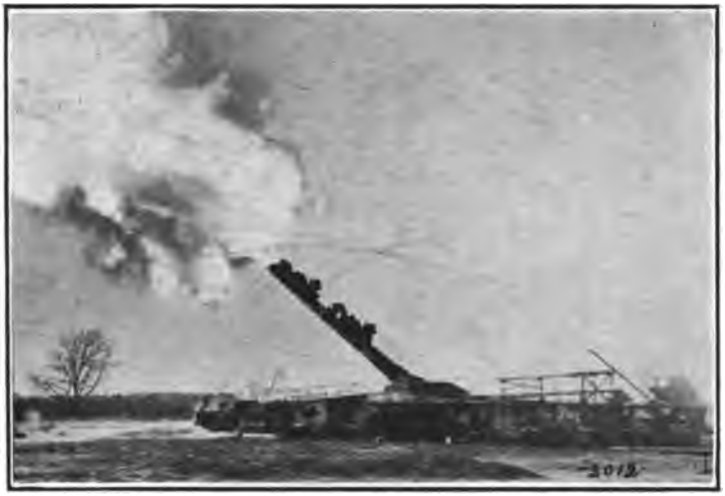
8-inch Barbette Gun on Railway Mount, showing "Foliage" forms of camouflage at near view in the open camoufleur should endeavor to correct these discovered flaws. It is of vital importance that our great railway mounts as well as our permanent emplacements for Coast Defense should be protected against mosaic aerial experts who strive to penetrate the camouflage of battery positions. The chief agents with which it is necessary to cope in the successful camouflage of artillery are:

1st — The Aeroplane
2nd — The Stereoscopic camera with telescopic range
3rd — The Rose-ray and other Filters
4th — Shadow Silhouette.



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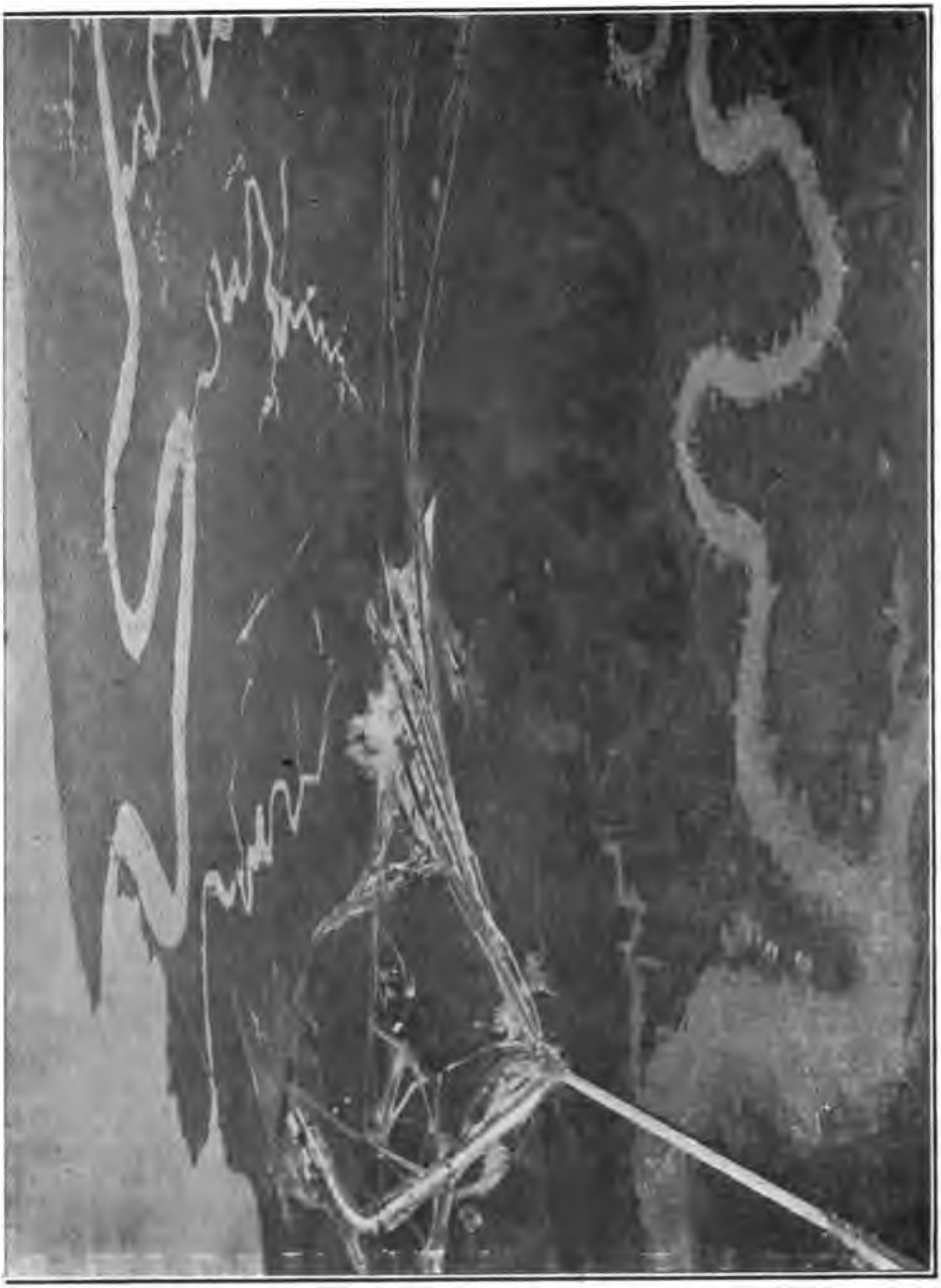
12-INCH SLIDING MOUNT---IN THE OPEN, SHOWING METHOD OF SECURING THE CAMOUFLAGE "FINS" AGAINST THE EFFECT OF RECOIL

By scientifically attacking the problem the Ordnance Department has, within the last few months perfected and turned out at the Proving Ground a camouflage system that defeats all four of the above mentioned agents.

1st.—The aeroplane is defeated for the reason that it acquires false information only. Even at the very lowest altitudes, the real facts are hidden by the Five Color System.

2nd.—The stereoscopic camera that detects falsely delineated perspective or pigment-painted shadow, is defeated by: (a) the use of opaque pigments for near planes; (b) transparent pigments for far planes; (c) by the use of mauve in juxtaposition with its complement; (d) by yellow used to counter-act



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SNAPSHOT OF FIRING 16-INCH HOWITZER: TAKEN FROM AIRPLANE AT PROVING GROUND shadow; (e) by a scientific application of the laws of light and color; and (f) by the camouflage of shadow.

3rd.—The rose-ray filter which turns all green pigments to rose color and leaves the foliage green is defeated by the chemically prepared ray-proof pigments, which alter the color waves and defy both eye and camera.

4th.—The shadow silhouette which outlines railway mounts upon the ground is defeated by the "camouflage canopy," scientifically constructed to camouflage the shadow.

The "Bull-Tucker Sound Ranging Device" which detects the location of the gun by recording sound waves, has played a considerable part in the detection of gun locations. The report of the gun is recorded on ribbons that give an accurate reading from each microphone instrument, and from these readings the locations are calculated. Undoubtedly there is much to be discovered which will add to the usefulness of these instruments.

Nevertheless, according to the expressed belief of those promoting these devices, the very nature of the method of detection makes it necessary for the concealed gun to be *fired before it can be detected.* Therefore neither the color camouflage nor the overhead camouflage should be neglected. Both are essential in order to protect the gun-mount from being located by the aeroplane observer and the steroscopic camera. Otherwise a battery may be put out of commission before it is even put in action.

In order to defeat the recording microphones, there are many possible methods of camouflaging the sound direction, such as construction of sound deflectors, multiple over-lapping sound records and mufflers, etc. Besides these methods, heavy air currents and atmospheric density add also to the difficulty of accurate recording by microphones.

No stronger proof of the successful deception accomplished by the Five Color System could be offered than the steroscopic photographs taken of Railway Mounts at the Proving Ground. Even with photographs taken at an elevation of only 1200 feet directly over the mount, it is not possible to find the guns, although they stand on bare ground in an open tract with no covering other than the paint applied upon them. The mount resembles several small piles of brush with no visible features of a gun or car. This effect is produced by the use of the opaque green pigment which appears to stand up from the ground towards the eye, and the form presented resembles foliage. The brown shadow portion appears to be far below the green and is made to produce this false impression by the use of a transparent brown pigment separated from the opaque green by an atmospheric transparent color.

The irregular foliage shapes are made to appear like solid forms by surrounding them with narrow black border which stops the line of vision.

The method successfully used for the camouflage of field guns has proved unsuitable and inefficient when applied to the camouflage of the greater areas presented by the extensive side girders and platforms of the railway mounts.

In order to overcome these obstacles the Five Color System was devised. It apparently breaks up the mass of the railway mounts into several fragments or separate masses by the use of the Ultra-Visible colors in conjunction with colors that record no plane, and this system also disguises the true character of the visible portions. By the correct selection of pigments the plane of the surface upon which these are applied, may be made to appear in several different planes. Again, the scientific selection and application of colors will defeat visibility, and by chemical preparation of the pigments ray-filters are defeated. The real form of the gun is hidden by producing a foliage design as it appears from the aeroplane point of view. The shadow of the gun is camouflaged by the erection of a semi-transparent canopy.

OBJECT OF THE FIVE COLOR SYSTEM

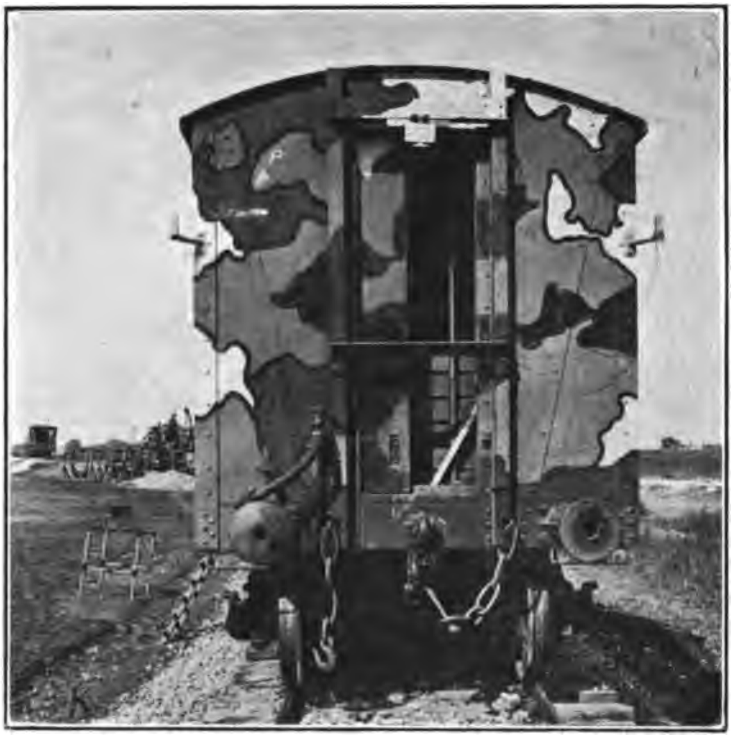
To resemble foliage; to compel the eye, on the one hand, *to record* the portions painted Green and Brown, and, on the other hand, to *fail* to record the portions painted Cream and Mauve. No attempt is made to blend the colors.

THE FIVE COLOR SYSTEM EMPLOYS:

Green, Cream, Brown, Mauve, and Yellow with a narrow border line of Black. The latter being used only to stop the line of vision. Cream is used to separate Green and Brown. Mauve is used in juxtaposition with its complement. So used it becomes non-recording. Yellow is used only to counteract Shadow.

Proportions of colors used in covering surfaces:

Brown	10	parts
Yellow	3	"
Cream	5	"
Green	10	"
Mauve	2	"

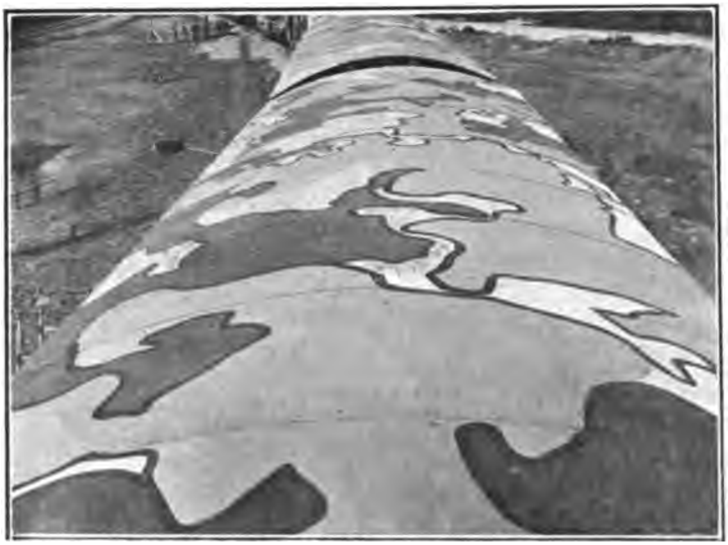


K 2298

END VIEW OF AMMUNITION CAR. SHOWING THE BLENDING EFFECT OF "MAUVE" ON SKY LINE AT SIDES OF CAR. THIS "MAUVE" ALSO BLENDS WITH THE BLUE SKY, OR WITH THE FOLIAGE WHEN SEEN WITH THE NAKED EYE.

If a canvas tent or opaque covering were used to hide the 'Railroad Mounts', the shadow would reveal the tent. Therefore, a wire net covering is used, into the meshes of which are woven opaque masses shaped to cast foliage shadows. In order to accomplish this, there must be left large open spaces in the netting. Through these open spaces the gun itself would be detected if it were not camouflaged.

In making the choice of the fifth color Mauve, it was found by experimenting that this color, when used on the outer edges, blended with both foliage and the atmosphere. This blending deceived with equal effect, both the camera and the naked eye. It was also demonstrated that the forms of certain portions of a gun, which might readily be recognized, could be effectually hidden by painting these parts Mauve in juxtaposition to a larger patch of its complementary color. In order to obtain the complement the rainbow spectrum disc was used.



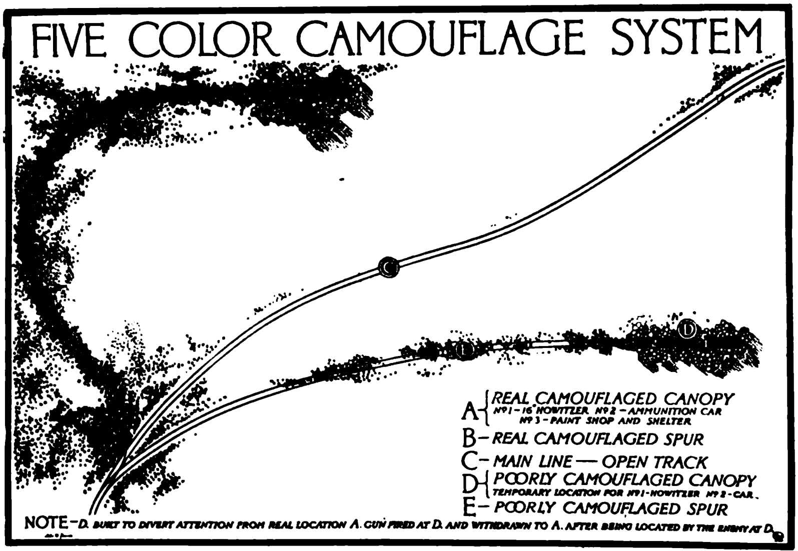
L 2290

Roof of Ammunition Car. Compare this flat, smooth color effect with the effect of uneven surface as seen from a few thousand feet in the air

The foliage forms as well as the form of their corresponding shadows were adopted because a clump of shrubbery does not appear out of place in most any landscape, hence it will attract the least attention.

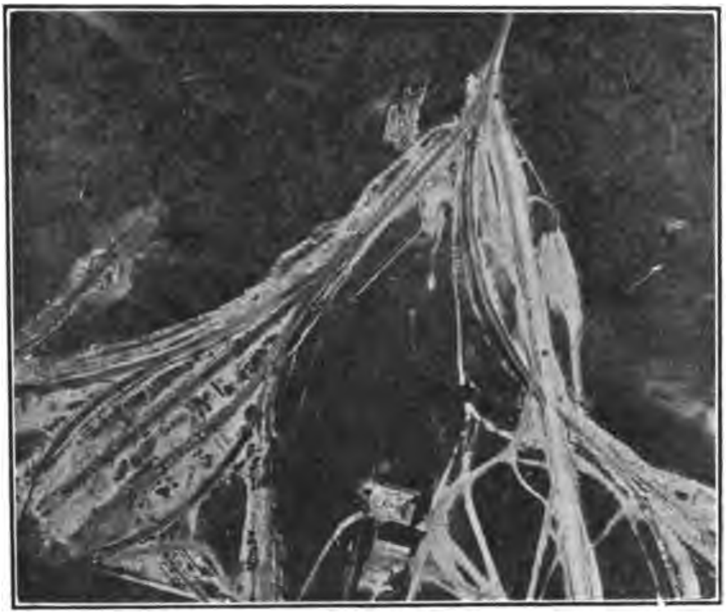
The study of the foliage forms should be from the aeroplane point of view.

The shadow of the recoil cylinders if projected onto the barrel of the gun will, if visible, reveal the form of a recoil cylinder. The portions of the barrel that receive such shadows should therefore be painted in colors that will absorb the shadow. The same is applicable to the shadow of the gun on the platform of the car.


FIVE COLOR CAMOUFLAGE SYSTEM
C
D
A { REAL CAMOUFLAGED CANOPY
Nº1-16" HOWITZER Nº2-AMMUNITION CAR
Nº3-PAINT SHOP AND SHELTER
B-REAL CAMOUFLAGED SPUR
C-MAIN LINE — OPEN TRACK
D { POORLY CAMOUFLAGED CANOPY
TEMPORARY LOCATION FOR Nº1-HOWITZER Nº2-CAR.
E-POORLY CAMOUFLAGED SPUR
NOTE-D. BUILT TO DIVERT ATTENTION FROM REAL LOCATION A. GUN FIRED AT D. AND WITHDRAWN TO A. AFTER BEING LOCATED BY THE ENEMY AT D.

M 2300

METHOD OF LAYING OUT "CAMOUFLAGED CANOPY" ON DOUBLE SPUR



N 2301

PHOTOGRAPH TAKEN FROM AIRPLANE ABOUT 1200 FEET ALTITUDE, SHOWING 16-INCH HOWITZER ON RAILWAY MOUNT AND 12-INCH MORTAR ON RAILWAY MOUNT, BOTH CAMOUFLAGED WITH THE FIVE-COLOR SYSTEM.

NO ATTEMPT IS MADE TO CAMOUFLAGE THE TRACK OR GROUND IN THIS PHOTOGRAPH.

THE 14-INCH NAVY RIFLE ON RAILWAY MOUNT IS NOT CAMOUFLAGED AND IS PLAINLY VISIBLE.

One purpose of the color patches is to render the shape of the gun unrecognizable and the other purpose is to break up the mass into what will appear to be several separate clumps of shrubbery.

The atmospheric color is used to separate the foliage mass from the ground shadow effect.

The yellow is used only on the under side of the mounts, and painted in irregular sun streak effects in order to break the shadow line into an irregular form, which will extend up into the foliage colors. This effectually conceals the cylindrical shape of the gun.

With this Five Color System carried out, not only the guns but also their railway mounts have been changed into an unrecognizable form. The location of the actual planes have also been manipulated so effectively that at a distance of only about 1500 feet above the mount, all resemblance to a gun has disappeared.

Photographs taken at this altitude, with the gun and car standing in the clear, indicate only broken forms which in no way attract the eye of an enemy. The gun and car are still less discernable at any greater altitude. One or more metal "fins" bound to the gun and cut in outline to resemble foliage silhouette, (while, at the same time, painted to blend with the camouflage patches on the gun barrel), will break the skyline of a long gun and carry the eye away from the gun form.

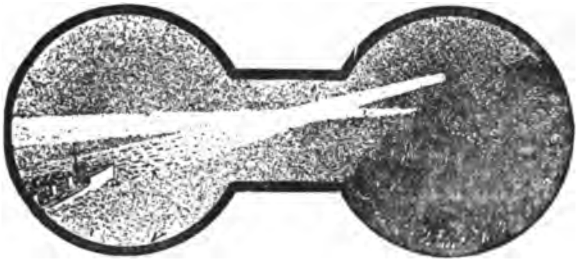
The Camouflage Canopy, which consists of a folding metal framework in separate towers, is easily packed in nesting shapes. In a few hours it can be erected and secured in place by wire cables. This feature is an essential part of the Railway Mount Camouflage. It protects against the shadow silhouette as photographed by the steroscopic camera from the aeroplane. The shadow outline of the canopy must blend with the structural outline of the gun mount.

In order to break the line of vision, bow-knots of canvas sprayed with paint are tied into the meshes of the net, which covers the framework of the canopy. These bow-knots occur at the large transparent sections of the net work.

Any marked deviation from the design in the Five Color System, in either form or color, will naturally defeat the aim.

In order to keep abreast with the advancing problems of camouflage, it is imperative that the research and experimental work should continue uninterrupted.

Without scientific research, camouflage is only an art and very limited in its possibilities, but connect this art with scientific experimentation, and the possibilities of camouflage will far exceed—even our present imagination.



Use of Railroad Artillery in Coast Defense

By Major Azel Ames, Coast Artillery

(Continued from March-April Issue.)

III

ORGANIZATION AND TRAINING

General.

(a) There has been a good deal of discussion of the degree to which railroad artillery should be self contained as to personnel and the idea seems to be prevalent that there is something esoteric about the railroad side of railroad artillery that would call for the assistance of other than artillery troops and make necessary a considerable departure in the organization of railroad artillery from that to be used for the horse or motor-drawn units. Even horse artillery requires, generally speaking, regularly built roads for its movement and the fact that the railroad artillery has to travel on a different kind of a road is no reason why its personnel should not be as capable of getting it over the road as the personnel of the horse or motor drawn guns.

It is true owing to the inability of two trains to pass each other on the same track and other features inherent in railway operation, there are certain limitations imposed on the handling of vehicles on railroads, but these limitations are so definite and the procedure to be followed in the conduct of movement by rail so well established and so readily studied that there should be no difficulty in instructing officers and men in its application. From experience with all three the writer is convinced that locomotives and motor trucks are much easier to control and repair than horses and it surely takes less training to make an engineman or chauffeur than to make a competent horesman.

We would not think of detailing cavalry to handle the horses of the light artillery nor having carpenters detailed from the Quartermaster Corps to put down the gun platforms for motordrawn howitzers. By the same token the railroad artillery should be able to run its engines, make road repairs of its rolling stock and put in frogs and switches and lay its firing tracks. It is just as much the railroad artillery's job to "get there" as it is to shoot and the responsibility for doing both equally well should fall on the commanders of all mobile artillery units.

Railroad artillery used in coast defense will have to travel almost entirely over the tracks of commercial railroads and in time of peace its movements except in important maneuvers will be subordinated to the commercial traffic. In time of war every available railroad employee will be so badly needed in the transportation of military units untrained in railroad work, that every man we have in the railroad artillery who can make a coupling or drive a spike will be a very great asset. There are five different ways to drive a spike which are incorrect; certainly a greater number of mistakes are possible in the loading and laying of a gun, yet we do not shy at teaching our men how to do it properly because it looks complicated or mysterious to the uninitiated. Railroad artillery troops cannot be profitably employed in extensive track building operations any more than other artillery troops in road construction, but the operation and care of their rolling equipment should be as much a part of their duties as shooting. Furthermore the track is their firing platform and they should be organized and trained to construct and maintain it.

The tables of organization for railroad artillery units so far published have been based on the requirements of field service in France where fixed targets only were to be fired at. For use against moving targets the horizontal base system of range finding will require a manning party for each end station and the plotting details required by the C.A.D.R. Transportation probably by motorcycles with side cars should be provided for both primary and secondary station details as well as the necessary reel carts and personnel for establishing the T. I. bell and telephone circuits to base end stations. The tide observers equipment where needed may be made light enough to be carried by the observer and his data transmitted visually or by messenger. If the artillery units are to provide their own meteorological data, as seems desirable, the necessary personnel, transportation, and equipment must be included.

Searchlight details and equipment should accompany each group headquarters as well as their necessary fire control and communication equipment, personnel and transportation, though it would appear doubtful if a fire command tracking, plotting, and relocating outfit would always be required.

Heretofore our tables of organization called for one Engineer, C.A.C., and one Fireman, C.A.C., for each locomotive. These enlisted specialists, no matter how thoroughly trained in our excellent school, are entirely incompetent, so far as this instruction goes to handle locomotives. It requires a little skill to take a train up a grade, but a great deal to take it down. The craft of the locomotive enginemen is not primarily in his knowledge of steam, but his knowledge of the air-brake. Of course he must know train rules thoroughly, but his skill as an air-brake operator is his principal asset. Some of our men must be trained in the repair and operation of the air-brake. Every railroad of any account has an air-brake instruction car and advantage could be taken of its stay at the nearest division point to put details from our units through the course. An instruction outfit similar to that in these cars should be installed at the Coast Artillery School, as well as some sample trucks, draft rigging, couplers, etc.

If there is anything that requires a base from which to operate it is a locomotive and it is believed that until such time as the amount of railroad artillery material in each district would warrant the construction of military shops and engine terminals therein, arrangements for the stationing, supply and repair of our railway artillery rolling equipment can best be handled by arrangement with the U. S. Railroad Administration or with the commercial railroads. In the formative period of our railroad artillery, nothing will better help the acquisition of knowledge of railroad matters, than the constant association of our officers and men with the plant, equipment, methods and personnel of the commercial railroads. Much that is not in the books will be learned by observation and once absorbed can later be put into our own textbooks.

The worst place to station our railroad artillery units would be at harbor forts. Most of them have no railroad trackage. Our personnel will probably not be so large that we cannot afford cantonment trains. Certainly a considerable portion of the time of our railroad artillery troops should be spent not only living on these trains, but travelling on them, starting out from the railroad division points on which they are based, travelling over the road to the various positions in their territory, occupying them, setting up their fire control and communications and having drill and target practice there, both summer and winter, especially the latter, when many conditions effecting the care and handling of railroad material arise that are absent in warm weather.

It will be just as detrimental to railroad artillery to keep it standing still as to do the same thing with horse artillery. It must be constantly exercised in movement to preserve the mobility which is its true "*raison d'etre.*" Not only will frequent movement be necessary to keep the material functioning properly and the man expert in its use in all sorts of different situations, but frequent visits to the various positions in its territory are necessary to give the officers, observers, etc., that familiarity with the aspect of their fields of fire which is essential to proper observation and identification of targets.

An important function of road work is to train enginemen and pilots, as it is a rigid rule of all railroads that no engineman unaccompanied by a pilot may run an engine over any division until he has made a sufficient number of trips over it with an instructor, to become acquainted with the location of grades, curves, crossings, sidings, stations, and signals. In time of a concentration of troops due to threatened invasion the principal duty of the locomotive enginemen employed on the divisions effected will be to act as pilots for the greatly increased number of trains coming in manned, not only by crews from other divisions of their own road, but from foreign roads as well. It is desired here to emphasize the necessity of having our peace time training of railroad artillery such as to make it as nearly self contained, self sustaining and as independent as possible of assistance from the commercial organization that will in time of war be overburdened.

The unexpected so often happens in war that we cannot presuppose that we shall find, especially if the enemy forces us inland, that we have all the firing tracks we need or that they are just where we want them. To throw in a frog and switch and lay enough track to hold their own outfit, should be something all in the day's work to the personnel of a railroad battery. Not that they would expect in general to build their own firing tracks, still less the approaches, but to be able to do it and to have had practice in doing it are a true part of their job of "getting there."

Special troops.

(b) We do not attach men from the Signal Corps to the heavy artillery to do our visual signalling nor our field radio work and so far have not asked the Navy to man our mine planters or smaller boats, but in the same way that we have mine companies in our large harbor defense commands, so it will probably be desirable to have attached to the larger railroad artillery units some strictly "Railroad Companies" yet composed of artillery personnel. It will be some years before we can complete our system of triangulation and quadrillage for the whole of our seaboard areas, lay out all the necessary base lines, establish the monuments to mark base end, B.C., and other stations, directing points, etc., build firing tracks and approaches, and establish railroad artillery terminals, with engine houses, repair sheds, barracks, etc. This period should be utilized in building up our railroad companies as well as our railroad artillery batteries and it will take broad-mindedness and strong handling to prevent over-specialization. As much of this preparatory work as will be good training should be done by the railroad companies whose work in time of peace should be:

a. Maintenance of railroad artillery tracks and equipment.
b. Training as railroad artillerymen.
c. Training in the simpler railroad operating duties necessary to get their outfits over the road in case of withdrawal of civilian personnel from the front.

In time of war the duties of the railroad companies should be:

a. Installation of firing and approach tracks with necessary small bridges, epis, etc.
b. Maintenance of roads, bridges, approach tracks and other facilities of its unit, especially repairs of damage to tracks from enemy fire.
c. Furnishing men to the batteries to replace losses.
d. Absorbing civilian railroad employees called or drafted into the railroad artillery service.

The principal value of these troops lies not as much in their possessing any special knowledge, for there is little that they should know which some of each battery personnel ought not to know, but in having them available to do repair work, which the battery personnel will be too much engrossed in shooting or too much depleted by casualties to undertake.

These "Railroad Companies" should be instructed in the service of the piece and supply of ammunition, as well as the construction and maintenance of track and structures, repairs of rolling equipment and operation of locomotives, motor vehicles, small shops, water and fuel stations, interlocking plants, etc. This sounds like a good deal to an artilleryman but not half as much as a gunners qualification seems to the average railroad man. It would be an un-American confession of lack of energy and adaptability if we conceded for a minute that our men could not be both good gunners and good railroaders. Just as we now have special ratings for gunners, etc. in mine companies, we should have special ratings in railroad artillery, and the same for the motor-drawn artillery to stimulate qualification in their particular duties.

In time of peace the "Railroad Companies" could well be used as schools of instruction, men being sent to them from the batteries for instruction in those kinds of railroad work for which the equipment was not supplied to the batteries. Classes in minor shop work, simple bridge building and repair, laying turnouts, how to take on coal and water, to operate a simple interlocking plant, to interpret train rules and orders should be held in the "Railroad Companies" while in the batteries themselves the routine inspection and care of the locomotives and rolling stock, firing platforms, guns, carriages, ammunition, motor vehicles, and fire control should be taught. In time of war the railroad companies, whose personnel could be rapidly and effectively increased by drafts from civil life of men of railroad training, would be able to furnish a considerable number of men to the batteries to replace losses, as they would have had artillery training while the railroad men from civil life would already know their railroad work.

The writer believes that the only vocation a man should be taught in the army is how to fight, including whatever is necessary to that end. However, the training outlined above should please the advocates of vocational training in the army and anything we can do to furnish good men to the railroads from our discharged soldiers will dispose them to help us. Such arrangements should be made that in time of large drafts in war not all the railroad civilians are sent to the Engineers. In organizing his battalion of the 75th Artillery, the writer found 46 men of valuable railroad experience out of a personnel of 280, whereas in the 41st Artillery, organized after orders had been issued diverting all men of railroad experience to the Engineers, only 9 men of any real railroad experience could be found out of nearly 500.

At a time when fighting is imminent in any region the railroad organization will be principally employed in getting the civilian population out and the fighting forces in. A part of this latter task is moving the railroad artillery. No two railroads or divisions of the same railroad are alike and a great deal of lost motion will be prevented if we can at the proper time draft into the army a sufficient portion of the railroad personnel of the region to make up operating companies under previously selected and trained army officers and to fill up construction companies or make new ones. For coast defenses we can know our battle ground in advance and use a larger proportion of local personnel. For field warfare we shall probably need railroad labor battalions, composed principally of men from railroads remote from the theatre of operations, and assigned to the higher railroad artillery units. The same would be true to perhaps a less degree as regards operating companies or battalions.

Consolidation.

(c) The railroad artillery is only a part of the army, but unless the general health of the military body is good its members will not function properly. The army has seldom received from the people the support to which its purpose and mission entitled it and consequently has never been able to develop its various branches adequately. Two reasons for this condition are:

1. The public has never felt that there existed between the various arms of the service that unanimity of aim and action which were for its best interests and those of this country.

2. The army has not been a real part of the people but as much a thing apart as the Geological Survey or the Railway Mail Service.

A single list for promotion for the whole army, or as near an approach to it as is humanly possible will largely eliminate the first and a system of universal service is the only thing to cure the second. When the voters constitute the army it will become a thing of the people and they will treat it as their own and a part of themselves and not as simply one among the various instrumentalities of government. The present war has shown more clearly than ever before how much of the army's work is but an adaptation to military ends of the materials, men, occupations, and organizations of civil and industrial life. We can never hope to secure in necessary numbers by voluntary enlistment in competition with commercial in-industries the men of the multitude of qualifications needed for the conduct of modern war nor for an army of a size proportionate to our national standing and responsibilities.

As regards the railroad artillery, its functions in coast defense and inland warfare will be shared by our heavier motor-drawn artillery and supplemented by our lighter horse-drawn artillery. Any or all of these types of artillery may be engaged in harbor defense as well as in coast defense or mobile land warfare. We have seen in the present war Coast Artillery and Field Artillery regiments armed with the same material shooting at the same targets and serving under the same brigade commanders. Our railroad artillery manned by C.A.C. troops is at present more adaptable to the attack of inland stationary targets than of ships.

The functions of one type merge into those of another by graduations, too small for radical demarkation in organization or control to be more than empirical or artificial. A horse battery used to repel a raid on the searchlight stations of a seacoast fort is as much an adjunct to the conduct of naval war as a seacoast mortar. Will it not therefore be a measure of economy and efficiency if all the artillery of our army be merged into one corps composed of the necessary seacoast gun, mortar, and mine companies, anti-aircraft sectors, trench mortar battalions and regiments and brigades of horse, light, mountain, motor drawn, and railroad artillery, with their ammunition trains, artillery parks, repair units and railroad construction battalions?

The only gage we have a right to apply to this question is that of national needs and war time efficiency.

Instruction.

(d) No single textbook known to the writer covers the essentials of railroad building, upkeep, and working as fully in such condensed from as professional Papers No. 32, C. E., U. S. Army, Military Railways. It should be studied by all officers of railroad artillery and form the basis of the instruction of enlisted men. It should, however, be used as intended, namely, to supplement Part IV, Military Railways, of the Engineer Field Manual (Professional Paper No. 29, C. E.)

as there is some valuable matter in the latter not included in the former. It would seem that a new manual might well be prepared using the material in both the above publications, rearranging it and adding new material gathered from the experiences of our expeditionary forces in France and Russia.

It is noted that the railroad organization described for military railways in these publications is that employed on commercial railroads operating under what is known as the "Divisional" system of organization. Many railroads in the United States still operate under a less desirable organization known as the "Departmental" system. It is well for officers having to deal with railroad officials to understand the difference in order to know "who is who" on any particular road.

The following outline of a course of instruction for all railroad artillery personnel, commissioned and enlisted, is suggested:

1. *Operation.*
   a. Definitions and railroad terminology.
   b. Safety precuations to be observed when travelling or working on a railroad. Obstructions, fouling and clearance, Rule 99 Standard Code.
   c. Hand, flag and lamp signals.
   d. Audible signals.
   e. Classification signals and markers.
   f. Fixed signal and switch target indications.
   g. The explosive label, bad order card and car inspection signals.

2. *Way and Structures.*
   a. Definitions and nomenclature of the more common way and structure devices and parts.
   b. Names and use of the principal tools used in track and simple bridge building.
   c. Practical instruction in building or repairing a track.
   d. How to tell whether or not a track or switch is in safe condition to use.
   e. Safety precautions to be observed in using switches and in working around frogs, switches, guard rails and bridges.
   f. How to operate a truntable, a water standpipe, and a coal shute.

3. *Engines and Cars.*
   - a. Definitions and nomenclature of principal car and engine parts.
   - b. Names and uses of the principal tools used in work around cars and engines.
   - c. Practical instruction in coupling and uncoupling cars.
   - d. Brake rigging and how to use hand brakes, and renew a brake shoe.
   - e. Detection of major defects in wheels or running gear.
   - f. Lubrication. How to pack a journal and change brasses.
   - g. General principles of the airbrake. How to stop a train in an emergency, couple and uncouple air hose, and bleed a car.
   - h. Mechanical maneuvers, including use of screw and hydraulic jacks, blocking, replacers, switch rope, push pole and chains.
   - i. Maneuvering the special material assigned to the battery. Use of cranes, hoists, firing platforms, outriggers, floats, etc.

Selected personnel of each unit should be instructed in:

1. *Operation.*
   - a. Forms and reports pertaining to the railroad matériel of artillery.
   - b. Train rules and train orders.
   - c. Telegraphy, including railroad telegraph abbreviation and signals.
   - d. Operation of simple interlocking plants.
   - e. Billing, checking and receiving military freight.

2. *Way and Structures.*
   - a. Frog and switch work.
   - b. Simple bridge work.
   - c. Minor interlocking repairs and adjustments.
   - d. Maintenance of more common forms of railroad electrical apparatus.
   - e. Drawbridge operation.
   - f. Bridge warnings and loading gages.
   - g. Snow fighting.

3. *Engines and cars.*
   - a. Anatomy of locomotive.

b. Anatomy of freight cars.
c. Maintenance and operation of air brake system.
d. Road repairs of engines and cars.
e. Locomotive firing.
f. Locomotive running.
g. Wrecking.
h. Care of mess, bunk, tool, and other special cars including sanitary arrangements.
i. Car heating, lighting, water supply and latrine apparatus.

We need to instruct and train not only the men we have but those we expect to call into service, especially as officers, in time of war. It is suggested that the excellent work being done by the Coast Artillery School in co-operating with the colleges and technical schools to give gunnery and other artillery instruction be extended to cover the engineering and railroad societies. Many young engineer graduates who have not served in the heavy artillery in this war, especially those employed on railroads, would be glad to pursue a correspondence or evening course which supplemented by a period in summer training camps would lead to a commission in the Reserve Corps. Certificates of proficiency for prescribed courses completed might be issued to railroad employees who in war would enter the enlisted grades.

IV

Relation of the Railroad Artillery to Commercial Railroads

In time of war even more truly than in time of peace the railroad traffic of the United States is the blood of its national life. We have seen during the present war, with our own territory uninvaded, a relatively small proportion of our male population serving in the Army or Navy and with a powerful centralized control assisted by the best brains and patriotic efforts of the most efficient railroad officers in the world, a degree of congestion of this circulatory system which at times even threated the success of our military operations. Imagine then the conditions likely to obtain on our railroads when perhaps with no more warning than our European allies had in 1914, we are plunged into war with a power or combination of powers, which may by a rapidly achieved naval success subject our sea frontiers to invasion.

For the Army to take over the railroads at such a time would be a much more complicated process than it would be for the railroads in time of a great flood, famine or earthquake to take over the Army to assist them in the rapid concentration needed for rescue or relief work in the stricken area. It is only by the most intimate association and whole hearted co-operation with the railroad organization and painstaking study of the railroad side of our coast defense problems that those who have to repel invasion of our extended shores by the only means by which enemy landings may be prevented, namely our heavy mobile artillery, can obtain the special knowledge and breadth of view necessary to a successful handling of the situation.

Real emergencies are almost the exception in army life. Even in this greatest of wars, probably less than one third of the officers of our permanent establishment have been in battle and the activities of war seldom arise more than once or twice and then only for a few months or years in the lifetime of the average army officer in this country. The life of the railroad operating officer, on the other hand, is a continual round of encounters with the emergencies arising from fire, flood, washouts, wrecks, storms and loss of communications to say nothing of those due to sudden and serious traffic congestions, car shortages, and strikes.

As railroad artillerymen we shall not have the time nor do we need to become expert railroad operating men but so long as the railroad is our only means of movement and the track our firing platform we must have a full understanding of the possibilities as well as the limitations of the railroad branch of our art, for while we call to our aid many sciences and make their application a profession, we shall find that in the handling of railroad artillery we are truly practicing an art.

Our railroad artillery both in peace and in war must use for its movement the right of way, main lines, sidings, bridges, tunnels, water stations, coaling plants, turntables, telegraph and telephone lines, interlocking plants, and block signal systems of commercial railways. In time of peace these will be manned by the civialian railroad personnel. The extent to which in time of war this personnel will be taken over by the Army or by some other governmental agency is a matter for most careful study and will be effected primarily by the nature and extent of military operations in any territory.

Needless to say the less we interfere either in peace or war with the normal functioning of the great railroad organism the better it will serve us.

The part of the railroad artillery game that the roads will have to play is, except for the possible exposure of their personnel to hostile fire, nothing different from what they are having to play every day. Their life business is "getting there." Let them understand what we want accomplished and they will not only help us, but show us how to help ourselves. We can't play the railroad artillery game in this country unless we artillerymen acquire and maintain a sympathetic understanding with the commercial railroads, learn their language and get in bed with them. We spend our lives getting ready to fight. They fight their part of our battle every day. We need them in our business.

Our railroad artillery in France has operated chiefly upon railroads that were strictly military and hence has not had to meet many of the problems it will have to meet at home, especially in peace time. Throughout the present war the railroads in the United States have been under a centralized control such as they never had before and have had to meet conditions of congestion of traffic and shortage of material and trained personnel never before encountered. The U. S. Railroad Administration has probably operated the lines with much less satisfaction to travelers and shippers than the privately owned organizations would have given in time of peace, but much more successfully so far as the conduct of the war is concerned than could have been done under private ownership. From a military standpoint government ownership or complete governmental control is highly desirable. The railroad outlook in this country is at present greatly confused. The Director General of Railroads rightly claims that the results of war time operation of the roads are no criterion of the service and saving their governmental operation in time of peace would accomplish.

The fear generally expressed is that any considerable continuation of government operation would lead to ultimate government ownership, which to most of those well informed appears highly undesirable. It may be that we shall see the railroads restored to private operations within a few months with more or less governmental control, (probably more than before the war), in which case it will be necessary for the military establishment to deal with them as private corporations.

There are some arrangements and methods instituted by the R. R. Administration during the war that the railroad companies may desire to perpetuate, either as private or governmental agencies, for example, the regional control. If congress will legalize and regulate some of the pooling methods employed under government management, the relations of the War Department to the roads can be greatly simplified.

If the railroads revert to their pre-war status in which the government regulated their rates with great thoroughness, but exercised relatively little control over their operations, it will be necessary if railroad artillery is to form a part of our military establishment and is to have its capabilities at all developed, for the most intimate and definite relations to be established between the War Department and the American Railway Association. This association has shown a very commendable spirit in co-operating in peace time with the instrumentalities through which the government touches the railroads, namely the interstate Commerce Commission. Undoubtedly some of this spirit may have been due to an enlightened self-interest, which courted regulation by the Federal Government rather than the very disturbing conditions incident to regulation by the several states and it is believed that the railroad companies would welcome a much more stringent Federal regulation than existed before the war, if it would assure freedom from state interference. Fortunately it has been judicially determined that in matters in which the Interstate Commerce Commission exercises jurisdiction the states cannot. It is not to be doubted that if the War Department will make known to the Interstate Commerce Commission and the American Railway Association its needs in regard to the handling of railroad artillery the fullest co-operation may be had. Of course, as long as the Railroad Administration continues its control it is the organization to be dealt with and it is suggested that advantage be taken of the experience gained by it during the war to obtain from it all the reports and information possible, to be used in studies of the relations to exist between the artillery and the railroads both in time of peace and time of war.

A most important work, from a military standpoint is being done by the Valuation Division of the I.C.C. So far as the writer is aware this division is the only branch of the government that has complete plans and data regarding all right of way, lands, bridges, trackage, plant, and equipment of the railroads. Collaboration with it should afford great economy in getting the information needed for a study of existing trackage and equipment.

The peace time training and movement of railroad artillery involves co-operation with the railroads on the following matters:

a. A study of existing trackage, bridges, tunnels and other structures on both main lines and sidings of both coastwise and inland roads to determine their adequacy as to strength, clearness and capacity for existing or proposed railroad artillery matériel.

b. A classification of trackage on the basis of what artillery matériel can be handled over it and what cannot.

c. Arrangements with the railroads for the improvement of clearance or strengthening of structures, both where the normal renewals by the railroad companies would make conditions satisfactory for the use of our heaviest material without added expense to the raliroads, and also where the estimated needs of the railroad would be adequately met by less expensive renewals, the government bearing any excess cost necessary to put the track and structures in condition to suit the needs of the heaviest railroad artillery matériel to be used there. The matter of turntables or wye tracks for turning railroad gun cars not having all around fire is of greatest importance.

NOTE.—The I.C.C. now has complete control of the standards for railway safety appliances (rolling equipment only) but has no jurisdiction over the standards of roadway or bridge construction.

d. Membership of the War Department in the Master Car Builders Association to standardize railroad equipment and to secure road repair of artillery rolling stock under M.C. B. interchange rules. This is absolutely essential where these vehicles are to be moved as freight unaccompanied by their own personnel in which case there could be no access to spare parts by the railroad personnel. Naturally the War Department must accept and pay the bills of the road making the repairs in transit without any certification by an officer of the army as to the performance of the repairs as there would be no officer present in such cases any more than in the case of cars belonging to other roads instead of to the United States.

e. Enforcement of the I.C.C. regulations for the safe transportation of explosives, inflamables and other dangerous articles and conformity therewith by artillery and railroad personnel in charge of loading and shipping ammunition. This includes not only the protection of our own matériel and permanent use of I.C.C. explosive labels on our own cars, but instruction of personnel in safety precautions concerning other explosives or dangerous shipments, commercial or government, encountered in trains or in yards.

f. Arrangements for acceptance and release of custody of trains moved by either railroad or artillery crews with definition of authority and responsibility of railroad and artillery personnel.

g. Arrangements for the use of railroad company pilots on trains operated by artillery personnel.

h. Determination of any necessary departures from standard forms of sidetrack agreements including provision for maintenance by railroad companies of approach and firing tracks wholly or partly on land owned or leased by the government.

i. Arrangement for the use for commercial traffic of new tracks built primarily for artillery use and vice versa.

j. Rules governing artillery personnel during temporary use of side tracks owned by railroads and on their right of way.

k. Arrangements as to rental or demurrage charges where railroad sidings are used for artillery material, including fuel, water, repair and supply arrangements for government owned locomotives while on commercial railroads. (M.C.B. interchange rules do not apply to locomotives.)

l. Arrangement for wrecking charges and use of wrecking equipment and care of disabled artillery rolling stock wrecked while in transit unaccompanied by its own personnel.

m. Arrangement for use and charge for snow fighting, track laying, and weed burning equipment.

n. Arrangement for use of air-brake and other instruction cars, belonging to railroads and for instruction of officers or men in railroad schools.

o. Arrangement with American Railway Association and technical railroad societies for supply of latest official changes in rules and standards.

p. Arrangement for the use of railroad locomotives and crews for temporary movement or visits of artillery trains to firing positions for drill practice.

q. Arrangements with railroads for investigation of accidents or damage to U. S. property on railroads by military boards or courts having legal status rather than by railroad official investigation having no legal status.

r. Standardization of requirements of instruction and examination of artillery personnel who may be assigned to train operation.

Many other matters would doubtless arise requiring our getting together with the railroads. It cannot be expected that all of them will develop until we and they have together had experience in war, but our manifest duty lies in exercising as great foresight as possible and settling as soon as possible with the railroads all matters of common concern. A word from the War Department will put at its disposal through the various governmental and technical organizations mentioned above, plans, data, and information and the time and brains of competent railroad men glad to serve without compensation on boards or in consultation. The views of these men who before the war knew nothing of military affairs will now have an enhanced value through their association with the problems that the railroads have had to meet with while the war was in progress.

It is fully realized that in time of war, and with the railroads under military control, those officers of the Quartermaster Corps or of the Corps of Engineers who will be in charge of military railways will have an adequate idea as to the transportation needs of the railroad artillery. They will, however, be concerned largely with administration problems and the existing railroads of the country will become "Supply Railways" as defined in Pars. 2 and 32 of Professional Papers, No. 32, C.E., U.S. Army, Military Railways, Revised Edition, 1917. They will have little or nothing to do with the railroad artillery in time of war from the time it clears the main line, until its mission on its firing tracks is completed, it has again become a part of the main line traffic to move to some remote position or to some rear area. In time of peace the military railway personnel will have nothing to do with railroad artillery while on commercial railroads so we must for that reason if for no other learn to take care of ourselves.

APPENDIX "A"

Estimated Cost of Track per Linear Foot

MAIN LINE

Item		Quanity	Unit Price	Cost
Crushed Stone Ballast (Standard Plan A-1)		0.51 cu. yd.	1.30	0.663
Yellow Pine Ties (Treated)	20 ties to each 33 foot rail	0.61 ties	2.50	1.525
Rail	6" – 105 (2240 – 1 ton).	0.03125 tons	68.25	2.130
Angle Bars	6" – 105	0.0606 pairs	3.00	0.182
Bolts	6 bolts per pair of angle bars	0.3636 bolts	0.08	0.030
Spikes	8 spikes to each tie (484)	4.07 spikes	5.83	0.237
Tie Plates	2 tie plates to each tie	1.22 plates	0.40	0.488
				5.250
			Labor	0.850
			Total	6.10

SIDE TRACK

Item		Quantity	Unit Price	Cost
Cinder Ballast		0.43 cu. yds.	0.45	0.194
Yellow Pine Ties	18 ties to each 33 foot rail	0.55 ties	2.20	1.210
Rail	6" – 100 S&Y	0.028274 tons	60.00	1.696
Angle Bars	Second hand	0.0606 pairs.	2.50	0.152
Bolts	6 bolts per pair of angle bars	0.3636 bolts.	0.054	0.020
Spikes	6 spikes to each tie	2.75 spikes	5.00	0.138
Tie Plates	2 tie plates to each tie	1.10 plates	0.30	0.330
				3.740
			Labor	0.660
			Total	4.400

TURNOUTS

Frog. No.	7		8		10	
Class	New	2d Hnd.	New	2d Hnd.	New	2d Hnd.
Material	$1033	$819	$1115	$873	$1266	$1016
Labor	117	101	120	102	144	124
Total	$1150	$920	$1235	$975	$1410	$1140

Note:—The costs given for turnouts included the tracks from which the turnouts is taken: i.e., they include all trackwork between the center-line of the first head-block and the center-line of the the last switch tie.

The above is taken from an estimate sheet of an important railroad. Prices are revised to January, 1919. Cost of track using different weights of rail can be computed from the unit prices given above. Grading from borrow pits along the line can be done at from 40c to 60c per cubic yard. Material hauled in by train will cost from $1.00 to $2.00 per cubic yard. Cost of necessary right of way, bridges and culverts should be added.

APPENDIX "B"

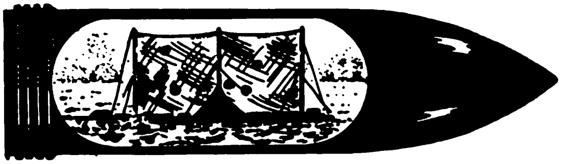
ESTIMATED CHARGE PER DAY FOR USE OF ENGINE AND TRAIN CREW

When it was proposed to station 7-inch Naval Guns on railway mounts at Marathon, Fla., in July, 1918, to protect the viaduct of the Florida East Coast Railway, the railroad company presented the following estimate of charges, based on having one locomotive and caboose stationed there with the three crews required under the Hours of Service Law to afford service at any hour of the day or night.

Fuel and water charge is based on a run of 100 miles per day and is the same whether the train moves or not:

Rental of engine	$20.00
Fuel, water and mechanical expense	68.00
Caboose and transportation supplies	1.00
Three crews—8 hr. shifts	67.80
Rental of Tank car for oil fuel	2.00
Total	$158.80

The above figures adjusted on the basis of one crew for each 8-hour shift would be substantially correct for use of commercial engines and train crews handling railroad artillery from base to firing positions for drill or practice. With artillery locomotives and qualified crews the railroad company would bill for use of trackage and service of pilot only.



ASTRONOMIC DETERMINATION OF DIRECTION*

By Captain Edward M. Burd, Coast Artillery.

Whenever artillery is fired at invisible targets the determination of the direction of the gun-target line is perhaps the most vital element of the system. Present indications point to the firm establishment of indirect methods of fire for heavy artillery used in land warfare. With increasing range it is not improbable that seacoast armament may be fired more by Case III in the future than in the past. While a position-finding system need not necessarily be oriented, it requires but little more work and is a great deal more convenient to have all directions indicated by their true azimuths, and is almost essential when it comes to extending the system or connecting it to other systems. Consequently, the Artillery Officer is confronted with the necessity for determining true north—geographic north—whenever firing data is to be prepared, or any surveying or map work is to be done.

During the past emergency great efforts have been made to extend and improve the art and science involved in the use of artillery, and Meridian Determination has received its full share of attention. The two or three methods more or less standard among Army and civilian engineers have been increased to about a dozen. Many of the supposedly new methods are put forth without any apparent hesitation, to say the least. The practical astronomer or the experienced field engineer, knowing that the subject has been exhaustively investigated for hundreds of years, would suspect that in time the more impractical methods will naturally gravitate into the discard—a survival of the fittest. But most of us are too busy with other duties to become accomplished scientists, and when we need to make a determination of direction it is desirable that some ready reference indicate the procedure for two or three of the more suitable methods, saving time and thought which might otherwise be wasted on impractical academic solutions of the problem.

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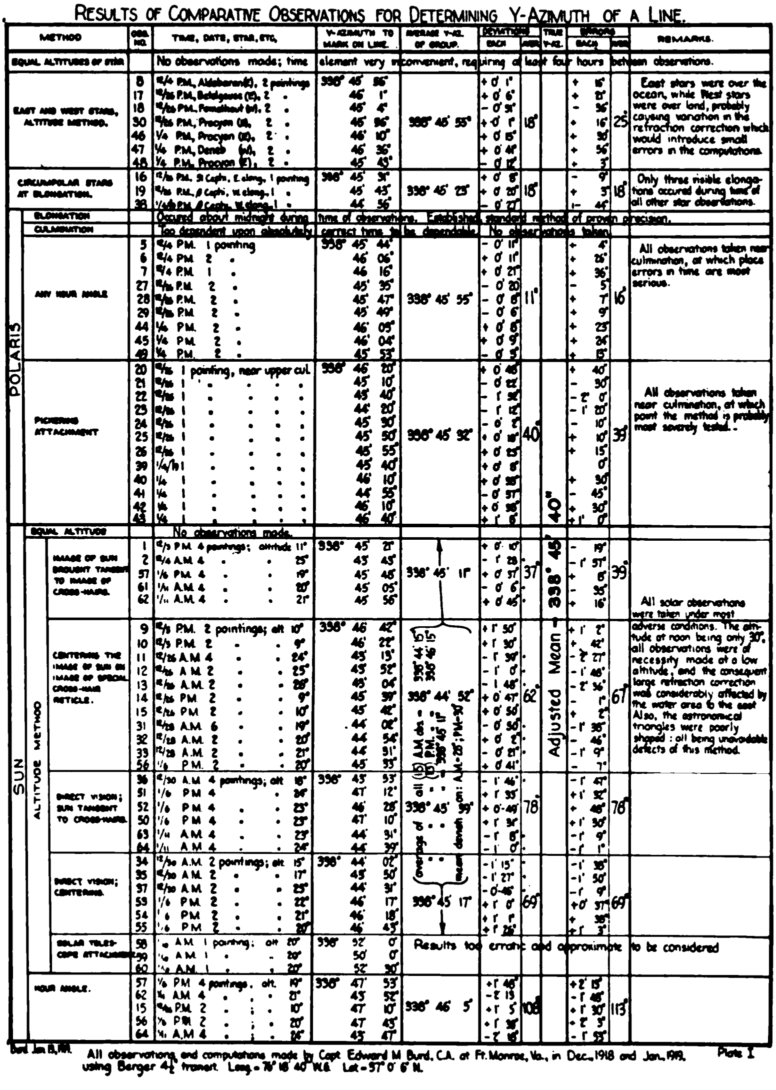
*A comparison of the many methods, with a general statement of the principles involved in each, and of its advantages and disadvantages for actual field use.



RESULTS OF COMPARATIVE OBSERVATIONS FOR DETERMINING Y-AZIMUTH OF A LINE.

		METHOD	OBS. NO.	TIME, DATE, STAR, ETC.	Y-AZIMUTH TO MARK ON LINE.	AVERAGE Y-AZ. OF GROUP.	DEVIATIONS EACH	DEVIATIONS AVER.	TRUE Y-AZ.	ERRORS EACH	ERRORS AVER.	REMARKS.
		EQUAL ALTITUDES OF STAR		No observations made; time element very inconvenient, requiring at least four hours between observations.								
		EAST AND WEST STARS, ALTITUDE METHOD.	8	12/4 P.M., Aldebaran (E), 2 pointings	338° 45' 56"		+ 0' 1"			+ 16"		East stars were over the ocean, while West stars were over land, probably causing variation in the refraction correction which would introduce small errors in the computations.
			17	12/26 P.M., Betelgeuse (E), 2 "	46' 1"		+ 0' 6"			+ 21"		
			18	12/26 P.M., Fomalhaut (W), 2 "	45' 4"		− 0' 51"			− 36"		
			30	12/26 P.M., Procyon (W), 2 "	45' 56"	338° 45' 55"	+ 0' 1"	18"		+ 16"	25"	
			46	1/4 P.M., Procyon (E), 2 "	46' 10"		+ 0' 15"			+ 30"		
			47	1/4 P.M., Deneb (W), 2 "	46' 36"		+ 0' 41"			+ 56"		
			48	1/4 P.M., Procyon (E), 2 "	45' 43"		− 0' 12"			+ 3"		
		CIRCUMPOLAR STARS AT ELONGATION.	16	12/16 P.M. δ Cephi, E. elong., 1 pointing	338° 45' 31"		+ 0' 6"			− 9"		Only three visible elongations occured during time of all other star observations.
			19	12/16 P.M. β Cephi, W. elong., 1 "	45' 45"	338° 45' 25"	+ 0' 20"	18"		+ 5"	18"	
			38	1/4/19 P.M. β Cephi, W. elong., 1 "	44' 56"		− 0' 27"			− 44"		
POLARIS		ELONGATION		Occured about midnight during time of observations. Established standard method of proven precision.								
		CULMINATION		Too dependent upon absolutely correct time to be dependable. No observations taken.								
		ANY HOUR ANGLE	5	12/4 P.M. 1 pointing	338° 45' 44"		− 0' 11"			+ 4"		All observations taken near culmination, at which place errors in time are most serious.
			6	12/4 P.M. 2 "	46' 06"		+ 0' 11"			+ 26"		
			7	12/4 P.M. 1 "	46' 16"		+ 0' 21"			+ 36"		
			27	12/26 P.M. 2 "	45' 35"		− 0' 20"			− 5"		
			28	12/26 P.M. 2 "	45' 47"	338° 45' 55"	− 0' 8"	11"		+ 7"	16"	
			29	12/26 P.M. 2 "	45' 49"		− 0' 6"			+ 9"		
			44	1/4 P.M. 2 "	46' 05"		+ 0' 10"			+ 25"		
			45	1/4 P.M. 2 "	46' 04"		+ 0' 9"			+ 24"		
			49	1/4 P.M. 2 "	45' 53"		− 0' 2"			+ 13"		
		PICKERING ATTACHMENT	20	12/16 1 pointing, near upper cul.	338° 46' 20"		+ 0' 48"			+ 40"		All observations taken near culmination, at which point the method is probably most severely tested.
			21	12/16 1 " " " "	45' 10"		− 0' 22"			− 30"		
			22	12/16 1 " " " "	43' 40"		− 1' 52"			− 2' 0"		
			23	12/16 1 " " " "	44' 20"		− 1' 12"			− 1' 20"		
			24	12/16 1 " " " "	45' 30"		− 0' 2"			− 10"		
			25	12/16 1 " " " "	45' 50"	338° 45' 32"	+ 0' 18"	40"		+ 10"	39"	
			26	12/16 1 " " " "	45' 55"		+ 0' 23"			+ 15"		
			39	1/4/19 1 " " " "	45' 40"		+ 0' 8"			0"		
			40	1/4 1 " " " "	46' 10"		+ 0' 38"			+ 30"		
			41	1/4 1 " " " "	44' 55"		− 0' 37"		Adjusted Mean = 338° 45' 40"	− 45"		
			42	1/4 1 " " " "	46' 10"		+ 0' 38"			+ 30"		
			43	1/4 1 " " " "	46' 40"		+ 1' 8"			+ 1' 0"		
SUN		EQUAL ALTITUDE		No observations made.								
	ALTITUDE METHOD	IMAGE OF SUN BROUGHT TANGENT TO IMAGE OF CROSS-HAIRS.	1	12/3 P.M. 4 pointings; altitude 11°	338° 45' 21"		+ 0' 10"			− 19"		
			2	12/4 A.M. 4 " " 25°	43' 43"		− 1' 28"			− 1' 57"		
			57	1/6 P.M. 4 " " 19°	45' 48"	338° 45' 11"	+ 0' 37"	37"		+ 8"	39"	
			61	1/11 A.M. 4 " " 20°	45' 05"		− 0' 6"			− 35"		
			62	1/11 A.M. 4 " " 21°	45' 56"		+ 0' 45"			+ 16"		All solar observations were taken under most adverse conditions. The altitude at noon being only 30°, all observations were of necessity made at a low altitude, and the consequent large refraction correction was considerably affected by the water area to the east. Also, the astronomical triangles were poorly shaped: all being unavoidable defects of this method.
		CENTERING THE IMAGE OF SUN ON IMAGE OF SPECIAL CROSS-HAIR RETICLE.	9	12/3 P.M. 2 pointings; alt 10°	338° 46' 42"	(average of all (15) A.M. obs. = 338° 44' 15" (15) P.M. " " = 338° 46' 15" 338° 45' 15" mean deviation: A.M.–28"; P.M.–30")	+ 1' 50"			+ 1' 2"		
			10	12/3 P.M. 2 " " 9°	46' 22"		+ 1' 30"			+ 42"		
			11	12/26 A.M. 4 " " 24°	43' 13"		− 1' 39"			− 2' 27"		
			12	12/26 A.M. 2 " " 25°	43' 52"		− 1' 0"			− 1' 48"		
			13	12/26 A.M. 2 " " 28°	43' 04"		− 1' 48"			− 2' 36"		
			14	12/26 P.M. 2 " " 9°	45' 39"	338° 44' 52"	+ 0' 47"	62"		− 1"	67"	
			15	12/26 P.M. 2 " " 10°	45' 42"		+ 0' 50"			+ 2"		
			31	12/28 A.M. 6 " " 19°	44' 02"		− 0' 50"			− 1' 38"		
			32	12/28 A.M. 2 " " 20°	44' 54"		+ 0' 2"			− 46"		
			33	12/28 A.M. 2 " " 21°	44' 31"		− 0' 21"			− 1' 9"		
			56	1/6 P.M. 2 " " 20°	45' 33"		+ 0' 41"			− 7"		
		DIRECT VISION; SUN TANGENT TO CROSS-HAIRS.	36	12/30 A.M. 4 pointings; alt 18°	338° 43' 53"		− 1' 46"			− 1' 47"		
			51	1/6 P.M. 4 " " 24°	47' 12"		+ 1' 33"			+ 1' 32"		
			52	1/6 P.M. 4 " " 23°	46' 28"	338° 45' 39"	+ 0' 49"	78"		+ 48"	76"	
			50	1/6 P.M. 4 " " 23°	47' 10"		+ 1' 31"			+ 1' 30"		
			63	1/11 A.M. 4 " " 23°	44' 31"		− 1' 8"			− 1' 9"		
			64	1/11 A.M. 4 " " 24°	44' 39"		− 1' 0"			− 1' 1"		
		DIRECT VISION; CENTERING.	34	12/30 A.M. 2 pointings; alt 15°	338° 44' 02"		− 1' 15"			− 1' 38"		
			35	12/30 A.M. 2 " " 17°	43' 50"		− 1' 27"			− 1' 50"		
			37	12/30 A.M. 2 " " 25°	44' 31"		− 0' 46"			− 1' 9"		
			53	1/6 P.M. 2 " " 22°	46' 17"	338° 45' 17"	+ 1' 0"	69"		+ 0' 37"	69"	
			54	1/6 P.M. 2 " " 21°	46' 18"		+ 1' 1"			+ 38"		
			55	1/6 P.M. 2 " " 20°	46' 43"		+ 1' 26"			+ 1' 3"		
		SOLAR TELESCOPE ATTACHMENT	58	1/10 A.M. 1 pointing; alt 20°	338° 52' 0"	Results too erratic and approximate to be considered						
			59	1/10 A.M. 1 " " 20°	50' 0"							
			60	1/10 A.M. 1 " " 20°	52' 30"							
		HOUR ANGLE.	57	1/6 P.M. 4 pointings, alt. 19°	338° 47' 53"		+ 1' 48"			+ 2' 13"		
			62	1/11 A.M. 4 " " 21°	43' 52"		− 2' 13"			− 1' 48"		
			15	12/26 P.M. 2 " " 10°	47' 10"	338° 46' 5"	+ 1' 5"	108"		+ 1' 30"	113"	
			56	1/6 P.M. 2 " " 20°	47' 45"		+ 1' 40"			+ 2' 5"		
			64	1/11 A.M. 4 " " 26°	43' 47"		− 2' 18"			− 1' 53"		

Burd Jan 13, 1919.

All observations and computations made by Capt Edward M Burd, C.A. at Ft. Monroe, Va., in Dec., 1918 and Jan., 1919, using Berger 4½ transit. Long. = 76° 18' 40" W.G. Lat. = 37° 0' 6" N.

Plate I

PLATE 1

2302

This article is the outgrowth of a series of experiments undertaken as a matter of purely personal interest, with the idea of making an impartial and unprejudiced comparison of the many methods from the standpoint of actual field use. A convenient line was arbitrarily chosen and permanently marked upon the ground, and some sixty separate and distinct observations were made to determine the azimuth of the line, using as many methods as possible. The observations and computations being all made by the same person, using the same transit, and keeping all other external conditions the same, the results should be fairly comparable. Also, no attempt was made to do the work with greater care or precision than would be expected of ordinary field work under rather unfavorable conditions, as will be evidenced by the results, which have been tabulated on Plate I. In fact, all the observations were made during rather disagreeable winter weather, and the results as here shown are not exhibited as a measure of the precision which should attend the planning and execution of the azimuth determination for any permanent or extensive work. Each and every observation made was computed and the results are here shown, regardless of the lack of agreement of those results, since the discarding of any observations would have vitiated the impartiality of the comparison. The results of all this work are shown on Plate I. No further comment or comparison of these figures appears to be necessary, as the reader will probably perfer to draw his own conclusion.

In the course of this investigation careful search on the subject was made through most of the standard texts on astronomy and surveying, the publications of the Coast Artillery School and of the Heavy Artillery School, A.E.F. Each authority usually limits its discussion to a few methods, explaining them in detail and possibly commenting upon their relative merits; but usually no general comparison is made, and the books do not necessarily select the same few methods from the number available. Plate II gives a summary of the apparent preferences of each authority, and indicates the detail and space allotted to each of the methods considered. An attempt has been made to estimate the order in which each authority would rank the methods, as indicated by the figures. An average or composite rank, as shown at the bottom of Plate II, has been made by averaging the individual figures. In a way this average may be assumed to approximate a fair ranking of the methods, judged largely by theoretical considerations by the best authorities on the subject.

This comparison has also been attacked from another angle, from the standpoint of engineers who have had actual field experience in this kind of work, and appreciate the shortcomings of each method from that point of view, which is only obtained by experience. This is the viewpoint most often lacking in books, and it was rather singular that in only one of the books just compared was any consideration given to the many points which always arise in the course of field

RELATIVE VALUE OF NINE METHODS OF MERIDIAN DETERMINATION
as taught at
HEAVY ARTILLERY SCHOOL, A.E.F. and
COAST ARTILLERY SCHOOL, FT. MONROE, VA.
and as deduced from
STANDARD ENGINEERING TEXTBOOKS.

Notation and numbers show apparent relative value as deduced from the treatment of the methods by each authority.

Kind of Observation / Name of Authority	STARS						SUN		
	Equal Altitudes of a Star	E. and W. Stars (Alt. method)	Circumpolar Stars at Elongation	Polaris			Equal Altitudes	Altitude Method	Hour Angle Method
				At Elongation	At Culmination	At Any Hour Angle			
Appendix to Part III, of "Notes on Heavy Artillery"; or Heavy Artillery School, A.E.F.		2 pages; apparently favored. 3		½ page of explanation. 5	1 page explanation. 6	2 pages of explanation; apparently favored. 2		4½ pages of explanation; apparently considered most necessary. 1	2 pages explanation. Probably is favored for emergency. 4
"Heavy Artillery Orientation." Coast Artillery School, Ft. Monroe, Va.	1 page of explanation. Precise, but not convenient. 3			1 paragraph; apparently considered inconvenient. 4	1 paragraph. Not favored. 5	6 pages of explanation; apparently strongly favored. 1		7 pages of explanation; apparently is considered to be necessary. 2	
Advanced Orientation Course, or Coast Artillery School.	Precise, but not practicable except in emergency. 6	Highly favored. 3	Precise, but too slow in most situations. 5	Very simple and precise, but wasteful of time. 2	Not favored. 8	Quick, fairly simple and sufficiently precise for general use. 1	Not favored 9	Not very precise nor simple, but the most convenient for general use. 4	Good only for emergency use. 7
"Text-book of Practical Astronomy" by Hosmer.	1½ pages; very good results but inconvenient. 4	1 paragraph. Considered good method. 5		4½ pages. Considered the most simple of all methods. 2	2 pages. Considered good. 6	6 pages. Stated to be the most precise. 1	1½ pages. Only fair. 7	4 pages; not as precise as Polaris, but very convenient. 3	
"Topographic, Trigonometric and Geodetic Surveying" by Wilson.				1 page. 3		6 pages and tables. Called precise, and evidently the most favored. 1		3 pages. Considered to be good, but only approximate. 2	
"American Civil Engineers Pocket Book" Merriman.		Considered good. 4		Referred to as "simplest accurate method." 1		Considered good when used with care and precision. 2		Considered good. 3	
"Higher Surveying," by Breed & Hosmer.				1 page. 2		6 pages; evidently favored. 1			
"Plane Surveying," by Tracy.	4 pages; evidently favored. 1							4 pages; considered practical. 2	
"Theory and Practise of Surveying," by Johnson and Smith.				3 pages. "Most precise method." 1		6 pages. Not as precise as elongation, but very convenient. 2			
Average rank	3.5	3.75	5.0	2.5	6.25	1.4	8.0	2.4	5.5

Burd. Jan. 9, 1919.

Plate II.

PLATE II 2303

work of observation, questions which often more vitally affect the results than minor defects in the theory. As a basis of comparison a rating scale was devised. It was used independently, without comparison with the others, by each of the officers who rated these methods. The results of these ratings are shown on the upper table of Plate III, being the upper, light-faced figures under each method. On the basis of each of these ratings the methods were ranked as indicated by the lower, heavy-faced figures. At the bottom

RELATIVE VALUE OF TEN METHODS OF MERIDIAN DETERMINATION

as indicated by the following independent ratings of
ORIENTATION INSTRUCTORS, COAST ARTILLERY SCHOOL, FT. MONROE, VA.,
who are also
CIVIL ENGINEERS, WITH CONSIDERABLE FIELD EXPERIENCE.

Upper figure is rated value; rated by accompanying scale
Lower, heavy figure shows relative position among the methods rated.

Method of Observation / Actual Experience of Rating Officer	STARS							SUN		
	Equal Altitudes	E and W. Stars	Circumpolar Stars at Elong.	Polaris				Equal Alt.	Altitude Method	Hour Angle Method
				Elong.	Culm.	Any Hour Angle	Pickering Attachment			
Washington Univ., and 7 years surveying and engineering practise.	85 **2**	73 **4**	68 **7**	68 **6**	63 **8**	70 **5**	86 **1**	80 **3**	57 **10**	58 **9**
Univ. of California. Instructor in astronomy	75 **4**	81 **1**	50 **9**	77 **3**	–	77 **2**	66 **7**	75 **6**	75 **5**	63 **8**
Columbia University. 10 years practise in engineering work	81 **3**	71 **7**	75 **5**	81 **2**	72 **6**	78 **4**	83 **1**	–	66 **8**	54 **9**
Rensselaer Polytechnic Inst., and 7 years engineering field work.	74 **6**	77 **4**	76 **5**	84 **1**	64 **8**	84 **2**	84 **3**	–	66 **7**	62 **9**
Mich. Agri. College, and 2½ years field work in engineering.	74 **2**	68 **5**	65 **7**	64 **8**	61 **9**	74 **1**	67 **6**	–	73 **3**	71 **4**
Univ. of Michigan. 9 years active practise, largely field work.	76 **4**	76 **3**	68 **8**	81 **1**	66 **9**	77 **2**	75 **5**	70 **6**	68 **7**	62 **10**
Average rating, as computed from above.	77.5	74.3	67	75.8	65.2	76.7	76.8	75	67.5	61.7
Average rank: (in order of highest aver. rating).	1	6	8	4	9	3	2	5	7	10
Average rank: (in order of highest average of individual rankings.	**3**	**5**	**8**	**2**	**9**	**1**	**4**	**6**	**7**	**10**

CONCENSUS OF OPINION

on the relative value of the several methods of Meridian Determination, as deduced by averaging the opinions of school publications, engineers' ratings and textbook writers' statements.

Average ranking by engineers, from above table. $\left(\frac{\text{sum}}{6}\right)$	3.5^{3}	4.0^{5}	6.7^{8}	3.5^{2}	8.0^{9}	2.7^{1}	3.8^{4}	5.0^{6}	6.7^{7}	8.2^{10}
Average ranking by schools and texts, from preceding plate.	3.5^{4}	3.75^{6}	5.0^{7}	2.5^{3}	6.25^{9}	1.4^{1}	not known	8.0^{10}	2.4^{2}	5.5^{8}
GRAND AVERAGE, in even units	3.5 **3**	3.83 **5**	5.85 **7**	3.0 **2**	7.13 **10**	2.05 **1**	3.8 **4**	6.5 **8**	4.55 **6**	6.85 **9**

Plate III

Ind. Jan. 10. 1919.

PLATE III

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of this upper table are shown the average ratings, the rank based upon this average rating, and the rank based upon the average of the individual rank figures. Due to the personal element the individual ratings are probably not as strictly comparable as the ranking; hence the average rank has been used at the bottom of Plate III in comparison with the average rank deduced from the data on Plate II. This final comparison is the most interesting one. There is a close agreement, with the exception of the Solar Altitude method. Concerning star observations there appears to be but little chance for argument in view of the rather close and similar grading of the methods which fall in the preferred half of the list, headed by Polaris Hour Angle, Polaris at Elongation, and Equal Altitude. There will always be a legitimate difference of opinion as to the best method, or as to the least desirable method, due to the particular situation in which the observation is to be made. But there seems to be little question as to whether any one method falls in the first half of the list or in the last half, and this is the main point of this comparison.

The rating scale upon which the engineers' ratings were based is on the scale of 100 for a method perfect in every particular. Of this total 45 points were assigned to field work, 35 to the theoretical considerations, and 20 points to ease of computation; representing the maximum values possible for perfection in each respect. Each of these divisions is again subdivided, all of which is a matter of judgement, of course, but a question upon which considerable time and thought was placed by several who are interested in the subject. A question may be raised concerning the advisability of giving the largest weight to field work, but those who have spent cold and generally disagreeable hours, often at night, trying to get a complete and satisfactory observation will readily agree with the relations here assumed. While precise results are always to be desired, this precision is all too often controlled by the ability to manipulate instruments quickly and dexterously, rather than by the theory of the situation. Skill and dexterity are largely affected by the simplicity of the field operations, for simple methods inspire confidence, the lack of which is fatal to most instrument work. In detail the rating scale is as follows:

1. *Ease and Quickness of Field Work*, a total of ----45 pts.
   a. Ease and certainty of distinguishing the object observed, -------------- 14

b. Availability of the method for use at any hour and under unfavorable weather conditions,	14	
c. Ease of handling the instruments used for observation,	8	
d. Freedom from the need for special attachments, precise time and other accessories,	9	
	45	
2. *Precision of Results*, a total of		35 pts.
a. Theoretical considerations, such as the shape of the triangles solved, lack of adjustment, time errors, etc.,	10	
b. Practical considerations, such as errors in pointing, reading time, verniers, etc.,	15	
c. Adaptability of the method to all places on the earth, as regards astronomical principles,	10	
	35	
3. *Ease of Computations*, a total of		20 pts.
a. Shortness and directness of method,	12	
b. Freedom from the necessity for special tables, formulas, or other data,	8	
	20	
Total,		100 pts.

In conclusion only the most broad and general statements appear to be advisable. The first question to be answered concerning any meridian determination is in regard to its use. If it is an original determination for the orientation of any new work or layout, or for any other reason should be precise to a matter of seconds, the means by which the information is to be obtained must be adapted to the precision required. This appears to eliminate solar observations. On the other hand, for quick and approximate determinations, as might be used for checking purposes, solar methods are well suited. Further specification seems to be unwarranted, as time of the year or of the day, location on the earth, instruments and time available, etc., are controlling conditions which will usually decide the question, rather than any general preference to one particular method. The effects of these local conditions and requirements, and the practical execution of each method are taken up in detail in the following discussion, upon the assumption that these points are least often considered in books or other reference works on the subject.

EQUAL ALTITUDES

Theory.—To an observer on the Earth, each of the so-called fixed stars appears to move around a circular path from east to west, the center of each circle being on the axis of rotation of the Earth. Each orbit lies in a plane, and the planes are all parallel to each other and perpendicular to the axis of the Earth. A line connecting two positions of any star on its circular path is a chord of its circle. The plane which is perpendicular to this chord, and bisects it, must pass through the axis of the Earth, intersecting the surface along a meridian. If an observer constructs a horizontal chord by selecting two positions of a star which have the same altitude, and measures the angle subtended by these two positions, the bisector of this angle lies in the perpendicular bisecting plane, and hence is a true north and south line. The fact that the observer is not on the axis of the Earth introduces no error. All this is easily accomplished by use of the engineer's transit. By intersecting the path of a star at equal altitudes the chord is established, the angle between its extremities is measured on the horizontal circle, and sighting the telescope along the bisector of the angle establishes a north and south line.

Practical Considerations.—Any star path may be used if, at the points to be observed, it is changing in altitude rapidly enough to give clear cut readings. A star near the meridian is changing too slowly in altitude to do this. Also, readings within ten degrees of the horizontal are too erratically affected by refraction to be dependable. The star selected should be changing rapidly in altitude and slowly in azimuth at the time of observation, and for convenience the altitude should be about 30 degrees, and the star should be at least two hours away from the meridian, requiring an elapsed time of observation of at least four hours. This condition may easily be realized on any clear night at any point on the surface of the Earth excepting when close to the poles, perhaps within 10 degrees of them, in which regions all stars appear to change in altitude very slowly. At all points in the temperate zones many stars will meet these conditions at all times of the night.

In the North Temperate Zone use is made of a special case of this general situation, well suited to give very precise results. In the winter season as soon as darkness comes some star within 20 or 30 degrees of the celestial pole may usually be found at eastern elongation, and its direction at that time may be found and marked on the ground with great precision, without regard to altitude. Some nine to twelve hours later, while it is still dark, the same star will be at western elongation and its direction at that time may similarly be marked upon the ground. The bisector of the angle between the two lines so marked points to true, or geographic, north. This is perhaps the simplest and the most precise use of this method, as not even altitude measurements are necessary.

The general case is also simple as no measurements of time or knowledge of latitude or longitude are required, and no tables of any kind need be consulted, only an observer and a transit being necessary. The minimum of about five hours of elapsed time between observations may be inconvenient, depending on the urgency of the work.

While the stars do not move in true circles the variation is too minute to be of any consequence. Observations made under the worst conditions, about six months apart, instead of five hours, would give from this cause a maximum error in direction of about 30 seconds. The instrument should be in good adjustment and carefully leveled during observation. If the vertical circle index is correct, all other errors of adjustment may be eliminated by making the first observation with telescope direct and the second with telescope inverted.

East and West Stars, Altitude Method

Theory.—The so-called Altitude Method of making observations on any star, planet, the sun or the moon, by means of which the direction of geographic north may be computed with the help of certain tabulated astronomical quantities, is the general case of which most of our methods are only some special adaptation. The East and West Star method is so named because in our latitude the observation of stars in these two regions of the sky allows easy manipulation of the instruments and furnishes well shaped triangles for computation. Theoretically the method is general and may be applied to any visible star.

The general case requires the solution of a spherical triangle; following an observation in which the horizontal angle from some fixed mark to the star is measured, and the angle of elevation of the star is measured, and the time of observation noted. All three sides are acrs of great circles of the celestial sphere. One side is the arc extending from the observer's zenith to the celestial north pole (in the northern hemisphere) and corresponds to the Earth's meridian from observer to pole, the direction of which is to be found. The length of this arc, in angular measure, is the complement of the observer's latitude, usually known or estimated with sufficient precision from a map. The second side of the triangle is the arc of the great circle extending from the observed star to the celestial pole, known as the polar distance of the star. Actually, this polar distance is found by adding, algebraically, 90 degrees to the declination, which is the angular distance from the star to the celestial equator. If the declination is north (usually marked + in an emphemeris) it is subtracted from 90 degrees to obtain the polar distance. Practically all visible heavenly bodies are studied by astronomical observatories and the declination is computed with great precision for several years in advance and published in the form of an ephemeris. The Nautical Almanac compiled by the Naval Observatory, Washington, D.C., is the most complete one obtainable in this country. Having an ephemeris, this declination may be determined, usually as a function of the time of observation, which must be noted when the observation is made. If the declination is changing rapidly the exact time must be noted, while if the declination is varying but little the time need be known only approximately. The declination of the fixed stars changes slowly, the maximum variation throughout a year being only about 50 seconds, hence the daily variation is of no importance in work of this degree of precision and the second side of the triangle is easily found by consulting an ephemeris without any exact time being necessary. The third side of the triangle is the arc of a great circle passing through the star and the observer's zenith. From horizon to zenith is 90 degrees. From horizon to star is the measured altitude (vertical angle corrected for the refraction, etc.). The difference is the third side of the triangle. Having three sides, the angle "A" at the observer may be computed by using the following formula from spherical trigonometry:

$$\tan \tfrac{1}{2} A = \sqrt{\frac{\sin(\text{S-lat.}) \sin(\text{S-alt.})}{\cos S \cos(\text{S-pol. dist.})}}$$

where S is the half sum, in angular measure, of the three sides of the triangle.

In making the observation it is necessary to measure the horizontal angle from some permanent mark to the star. In the spherical triangle the angle computed is the horizontal angle from true north to the star. Properly combining these two angles gives the angle from the mark to true north, which is the desired solution.

Practical Considerations.—The theoretical requirements for a complete solution are; (a) a well-shaped spherical triangle (observer-pole-star), (b) known latitude of the place of observation, (c) precise measurement of the horizontal angle from mark to star and the vertical angle to star (altitude), (d) time of observation within a few days, (e) an ephemeris and other means of computation. The practical means of supplying this data is usually the controlling factor, of this or any other method.

(a), (b), and (c) A well shaped triangle is obtained by selecting a star nearly east or west of the observer and about 25 to 40 degrees above the horizon. The variable side of the triangle is usually the altitude side, due to slight errors caused by refraction, aberration of light, parallax of the observer's position with regard to the center of the Earth, lack of precision in measuring the vertical angle, etc. The triangle should be so shaped that variation in the length of this side has but little effect on the magnitude of the angle at the observer. A triangle with a right angle at the star meets this requirement, which means an angle of 60 to 80 degrees at the observer. Stars should be chosen with this object in view. The latitude is usually determined from a map, in the absence of which an observation for latitude may be made.

In making the horizontal angle measurement all errors in the use of the instrument enter into the result at their full value. The instrument should be manipulated so as to eliminate the errors of adjustment as far as possible, taking readings on both star and mark with the telescope both direct and inverted. As the crosshairs may easily be set on a star with as much or more precision than the verniers may be read, for consistency there should be as many pointings at the mark as at the star. Two pointings at the star will give fair results as indicated by the computations on Plate I. Four would give better results, while for the maximum precision with a transit two sets of four pointings each made in eight to ten minutes of time will probably be best suited to most observers. As mentioned before, the weak link in this observation is the vertical angle, for the usual size and construction of the vertical circle does not allow as precise reading as the horizontal circle. In view of this special care must be taken in leveling the instrument and checking any index error of the vertical circle. The observed vertical angle must be corrected for refraction, always subtractive, and erratic for sights within ten degrees of the horizon. On the other hand sights at too great a vertical angle introduces other instrumental errors. The best angle is about 30 degrees. Other corrections of the vertical angle, due to aberration, parallax, etc., are too small to be considered in this class of work.

(d) The time of observation need be known only approximately, within a few days, which is a distinct advantage. In fact a very small and compact table may be prepared from an ephemeris, giving the declination of some forty of the brightest stars for the entire year.

(e) An ephemeris, or the table just mentioned, a table of logarithms, and a table of refractions are required for the computations, which are much less difficult than is generally supposed.

This method is fairly simple and may be used in any part of the world at any time the stars are visable. The brightest and most easily found stars may be used, and without any delay or waiting, and a fair observation may be made in four minutes. Two observations, one on an east and the other on a west star should give closely agreeing results and the average of the two will have errors of latitude, altitude, and refraction largely eliminated. Exact time is not needed. In partly cloudy weather even one pointing will give direction within probably two minutes. An observer can make a complete observation in ten minutes and the computations may easily be made in less than thirty, and the results may be expected to be in error less than thirty seconds; surely within a minute.

* * * * * * *

(To be continued)

Grid System For Progressive Maps in the United States

Prepared in the Office of the Chief of Engineers.
Tables and Formulae computed by the Coast and
Geodetic Survey in Co-operation with
The Chief of Engineers.

Projection

The earth's surface is spherical and in order that it may be represented on a map, it is necessary to show it on a plane surface. This necessarily means that no portion of the earth's surface can be shown in absolute accuracy on a map. There are various methods of approximating the surface of the earth on the plane, one of the most common of which is known as the Polyconic Projection.

A projection is simply a system of lines on a map representing imaginary lines on the earth's surface. The almost universal plan is to adopt a system of spherical coordinates based upon the plane through the poles and the observatory at Greenwich, England and the plane cutting the earth's axis at right angles midway between the poles. The first plane is called the initial meridian to which longitude or angular distances east and west are referred. The second plane is called the equator to which angular distances north and south or latitude are referred.

It is possible to locate by astronomic methods the longitude and latitude of any point on the earth's surface. The problem is how to show the location of some such point on a map with relation to the initial meridian and the equator.

There are various ways of showing meridians and parallels of latitude on a piece of paper, with relation to which various points on the earth's surface can be plotted, after their latitude and longitude have been determined. As mentioned above, one of the most generally used projections is what is called the Polyconic Projection. This is the one in which every parallel of latitude appears on the map as the developed circumference of the base of a right cone tangent to the sphere or spheroid on that parallel. The central meridian of this projection for any map will appear as a straight line, while all other meridians will appear slightly concave toward it. The parallels for this projection on any map will appear as arcs of circles of different radii with the centers of the arcs of circles on the central meridian produced beyond the limits of the map except in the case of the region at the north pole or the south pole. The equator alone of all the parallels will be represented on the map by a straight line and all of the other parallels will be convex toward it. The intersection of the various meridians and parallels for the polyconic projection will differ very little from right angles when the map covers a limited area in the east and west direction. The distance along the central meridian will be true to the scale of the map. This will also be the case of the distance along each of the arcs of the parallel but diagonal distances and north and south distances will be slightly in error, the error increasing with the distance from the central meridian.

It is readily seen when a section of the earth's surface, which is spherical, is flattened out to the plane of the map, that there must be some distortion in the distances as given by the map. If the central meridian is held true to scale, as is the case in the polyconic projection, and also the parallels are true to scale, then there must be some distortion as the edges of the map are approached. This will result in a sort of stretching or elongating of the area in a north and south direction.

For small areas the error in a polyconic projection is infinitesimal and can be ignored for even the very highest grade of map, but when the area approaches the dimensions of a number of square degrees, then the distortion at the east and west edges of the map may be material in size. In an area as large as the United States, the errors in a north and south direction along the Atlantic Coast and also along the Pacific Coast are as great as 6 per cent. This, of course, would make the polyconic projection a very poor one for an area of such a large extent.

With an area not greater than 10° of longitude in width, the error of a polyconic projection will be negligible so far as the scale of the map is concerned. For instance, at a distance of 5° east or west from the central meridian any distance in a north and south direction, as scaled from the chart, will differ from the true distance on the earth's surface by only .22 of 1 per cent. When it is realized that the hygrometric condition will expand or contract a map by as much as one per cent it is seen that the error of the polyconic projection is negligible.

Progressive Special Military Map

The polyconic projection shows the meridians and parallels as curved lines, except for a central meridian. With relation to these curved lines, points can be plotted whose geographic positions in latitude and longitude are known, but it is a difficult matter, requiring considerable time, to compute the distance and direction between two such points shown on a polyconic projection map. It, therefore, is not desirable to have such a projection on a map that is to be used for military purposes where distances and direction between objects must be computed in a very short time. Such a case is in the use of artillery. The Orientation Officer of a battery may wish to know quickly the distance and bearing from his gun to some point occupied by the enemy in order that the enemy may be fired upon. The only quick method of obtaining this distance is by a system of rectangular coordinates. The distance between the two objects whose coordinates are known would be the square root of the sum of the squares of the difference of the X coordinates and of the Y coordinates of the two objects. These differences make it possible to compute quickly the angle between one of the grid lines and the line joining the objects.

A system of rectangular coordinates could be used to cover any local area without regard to any other locality, but this makes an awkward situation when the maps of any two areas adjoin. The boundary between the two areas would be on different systems and much confusion would result. In order to obviate this, there has been adopted a plan by which a single system of grid coordinates covers all of the Atlantic Coast from some point on the coast of North Carolina to the northeastern part of the coast of Maine.

Grid Tables

In order that such a system of coordinates may be properly coordinated with positions as given in longitude and latitude, it is found to be necessary to have a polyconic projection covering a zone 9° wide in longitude and of indefinite extent in latitude. The central meridian of this projection is coincident with the 73rd meridian. A rectangular or grid system of coordinates with squares 1000 yards on a side is then projected over the whole area covered by the polyconic projection.

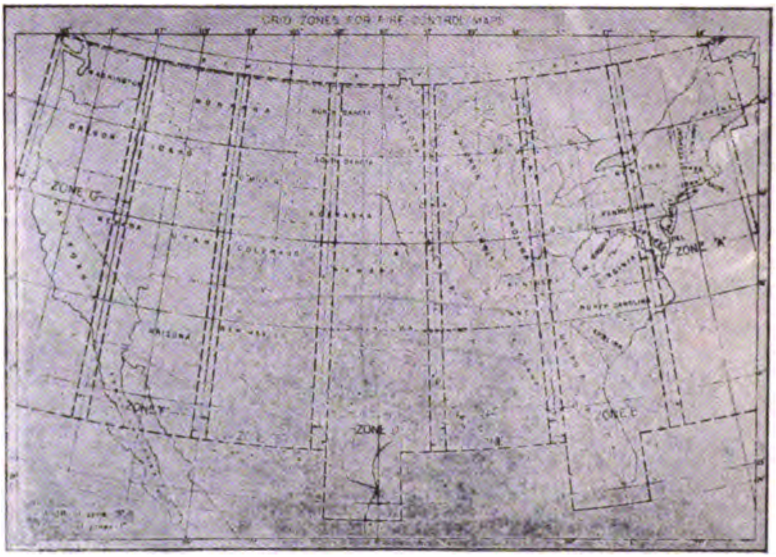


FIG. 1 2306

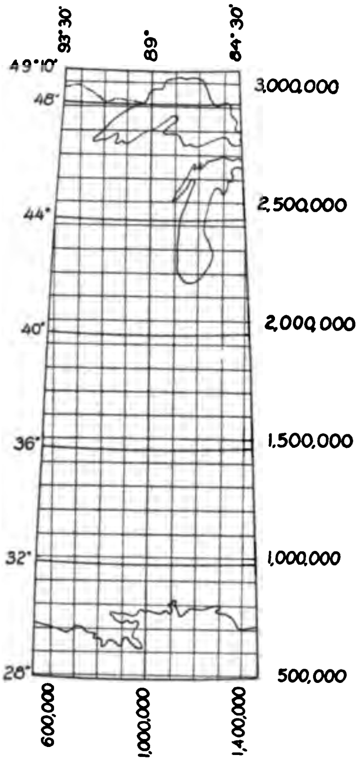
The intersection of the 73rd meridian of longitude and parallel 40° 30′ is the initial point of the grid system for this zone. All computations were made from that point, and a north and south line of the grid coincided with the 73rd meridian and an east and west line of the grid was tangent to the parallel of latitude of 10° 30′ at its intersection with the 73rd meridian.

Origin of Grid Coordinates

The computation consisted of determining the grid coordinates of all intersections of minutes of longitude with minutes of latitude within the area covered by the polyconic projection referred to above. After the computations were made a constant was applied to each of the X coordinates and another constant to each of the Y coordinates in order to make all of the coordinates positive within the area of the map. The point selected as the origin is 1,000,000 yards west and 2,000,000 yards south of the intersection at the 73rd meridian of longitude and parallel 40° 30′ of latitude.

EXTENSION OF THE SYSTEM

It is impossible to have a progressive map over a large area extending both east and west, north and south, without serious distortions in the projection. It is explained above that it is found advisable to restrict the zone within which the grid system could be used to °9 of longitude but an indefinite extent in latitude. The tables used for the special military maps above referred to were computed for the zone extending



SPECIAL MILITARY MAP'
One hundred thousand Yard Grid Lines
ZONE 'C'
FIG. 2 2306

4° 30′ of longitude in both the East and the West directions from the 73° of longitude, and from latitude 28° to latitude 49° 10′. Over the whole zone the grid projection is placed with the grid lines straight. Extensions of the table are made to cover the area in Maine to the eastward of meridian 68°

30′, in this zone, and to provide for other zones, the small area above the 49° of latitude at the Lake of the Woods near longitude 95°, and for Florida and Texas below latitude 28°.

The same tables can be used for any other zone having the same latitudes by simply changing the degrees of longitude When this is done it is possible to have the whole area of the United States covered. For instance the meridians in the tables which are now 68° 30′ to 77° 30′ can be changed to 77° 30′ to 86° 30′ when they can be used for placing the grid projection over the zone falling between those meridians.

			40° 30'		40° 31'		40° 32'		40° 33'		40° 34'	
			X yards	Y	X yards	Y	X yards	Y	X yards	Y	X yards	Y
Zone		'										
A	75°	00	1000000.0	2000000.0	1000000.0	2002024.0	1000000.0	2004047.9	1000000.0	2006071.9	1000000.0	2008095.9
B	81	01	998454.9	2000000.1	998455.3	2002024.1	998455.7	2004048.0	998456.0	2006072.0	998456.4	2008096.0
C	89	02	996909.8	2000000.6	996910.6	2002024.6	996911.3	2004048.5	996912.1	2006072.5	996912.9	2008096.5
D	97	03	995364.8	2000001.3	995365.9	2002025.3	995367.1	2004049.2	995368.2	2006073.2	995369.3	2008097.2
E	105	04	993819.7	2000002.3	993821.2	2002026.3	993822.8	2004050.2	993824.3	2006074.2	993825.8	2008098.2
F	113	05	992274.6	2000003.6	992276.5	2002027.6	992278.4	2004051.5	992280.3	2006075.5	992282.3	2008099.5
G	121	06	990729.5	2000005.3	990731.8	2002029.3	990734.1	2004053.2	990736.4	2006077.2	990738.7	2008101.2
		07	989184.4	2000007.1	989187.1	2002031.1	989189.8	2004055.0	989192.5	2006079.1	989195.1	2008103.1
		08	987639.3	2000009.3	987642.4	2002033.3	987645.4	2004057.2	987648.5	2006081.2	987651.6	2008105.2
		09	986094.3	2000011.8	986097.7	2002035.8	986101.2	2004059.7	986104.6	2006083.7	986108.0	2008107.7
		10	984549.2	2000014.6	984553.0	2002038.6	984556.8	2004062.5	984560.6	2006086.5	984564.5	2008110.5
		11	983004.1	2000017.7	983008.3	2002041.7	983012.5	2004065.6	983016.7	2006089.6	983020.9	2008113.6
		12	981459.0	2000021.0	981463.6	2002045.0	981468.2	2004068.9	981472.8	2006092.9	981477.4	2008116.9
		13	979913.9	2000024.7	979918.9	2002048.7	979923.9	2004072.6	979928.9	2006096.6	979933.8	2008120.6
		14	978368.8	2000028.6	978374.2	2002052.6	978379.5	2004076.5	978384.9	2006100.5	978390.3	2008124.5
		15	976823.8	2000032.8	976829.5	2002056.8	976835.3	2004080.7	976841.0	2006104.7	976846.7	2008128.7
		16	975278.7	2000037.4	975284.8	2002061.4	975290.9	2004085.3	975297.0	2006109.3	975303.2	2008133.3
		17	973733.6	2000042.2	973740.1	2002066.2	973746.6	2004090.1	973753.1	2006114.1	973759.6	2008138.1
		18	972188.5	2000047.3	972196.4	2002071.3	972202.3	2004095.2	972209.2	2006119.2	972216.0	2008143.2
		19	970643.4	2000052.7	970650.7	2002076.7	970657.9	2004100.6	970665.2	2006124.6	970672.5	2008148.6
		20	969098.3	2000058.4	969106.0	2002082.4	969113.6	2004106.3	969121.3	2006130.3	969129.0	2008154.3
		21	967553.2	2000064.3	967561.2	2002088.3	967569.3	2004112.2	967577.4	2006136.3	967585.4	2008160.3
		22	966008.2	2000070.6	966016.6	2002094.6	966025.0	2004118.5	966033.5	2006142.5	966041.9	2008166.6
		23	964463.1	2000077.2	964471.9	2002101.2	964480.7	2004125.1	964489.5	2006149.1	964498.3	2008173.1
		24	962918.0	2000084.0	962927.2	2002108.0	962936.4	2004131.9	962945.6	2006155.9	962954.7	2008180.0
		25	961372.9	2000091.2	961382.5	2002115.2	961392.0	2004139.1	961401.6	2006163.1	961411.2	2008187.1
		26	959827.8	2000098.6	959837.7	2002122.6	959847.7	2004146.5	959857.6	2006170.5	959867.6	2008194.6
		27	958282.8	2000106.4	958293.1	2002130.4	958303.5	2004154.3	958313.6	2006178.3	958324.1	2008202.3
		28	956737.7	2000114.4	956748.4	2002138.4	956759.1	2004162.3	956769.8	2006186.3	956780.6	2008210.4
		29	955192.6	2000122.7	955203.7	2002146.7	955214.8	2004170.6	955225.9	2006194.7	955237.0	2008218.7

FIG. 3. 2307

(ILLUSTRATIVE TABLE)

It is not practicable, however, to change the tables exactly 9° for if this is done the maps at the junction of the two zones would not have continuous grid lines, that is a map at the edges of one zone could not be exactly connected with a map having the same latitudes at the edges of the other zone and have the grid system continuous from one to the other. The grid lines of the two maps would make decided angles with each other.

In order to avoid this condition it is necessary to have an overlap of the two zones. This can be done by changing all of the longitudes of the tables as given for the most eastern zone by 8°. This would provide an overlap of 1° of longitude and the topography within this overlapping area could be shown on two sets of maps one on each grid system, thus making it possible to have progressive maps for each of the zones, or the two grid systems can be placed in different colors on the same map.

By changing the longitudes of the tables by 16° a third zone can be obtained and so on across the country in multiples of 8° of longitude.

The following table shows the designation of the several zones across the United States with their central meridians and the meridians which limit the zones.

			Lat. 42° 55'		Lat. 42° 56'		Lat. 42° 57'		Lat. 42° 58'		Lat. 42° 59'	
	Long.		x	y	x	y	x	y	x	y	x	y
Zone	°	'	Yards	Yards	Yards	Yards	Yards	Yards	Yards	Yards	Yards	Yards
A	70°	00	1267834.5	2298311.1	1267762.1	2300336.1	1267689.8	2302361.1	1267617.5	2304386.1	1267545.3	2306411.2
B	78	01	66346.9	258.2	66275.1	283.2	66203.8	308.2	66131.5	333.2	66059.5	358.3
C	86	02	64859.6	205.6	64788.1	230.6	64716.6	255.6	64645.2	280.6	64573.7	305.7
D	94	03	63372.2	153.3	63301.2	178.3	63230.1	203.3	63159.0	228.3	63088.0	253.4
E	102	04	61884.9	101.3	61814.2	126.3	61743.5	151.3	61672.9	176.3	61602.2	201.4
F	110	05	60397.5	2298049.6	60327.2	074.6	60256.9	099.5	60186.7	124.5	60116.4	149.6
G	118	06	58910.1	2297998.2	58840.2	2300023.2	58770.3	2302048.1	58700.5	073.1	58630.6	098.2
		07	57422.7	947.1	57353.2	2299972.1	57283.7	2301997.0	57214.3	2304022.0	57144.8	2306047.1
		08	55935.2	896.2	55866.2	921.2	55797.1	946.1	55728.0	2303971.1	55659.0	2305996.2
		09	54447.8	845.7	54379.2	870.7	54310.5	895.6	54241.8	920.6	54173.2	945.7
		10	1252960.4	2297795.4	1252892.2	2299820.4	1252823.9	2301845.3	1252755.6	2303870.3	1252687.4	2305895.4
		11	51472.9	745.5	51405.1	770.4	51337.2	795.4	51269.3	820.4	51201.5	845.4
		12	49985.4	695.8	49918.0	720.8	49850.6	745.7	49783.1	770.7	49715.6	795.8
		13	48498.0	646.5	48431.0	671.4	48363.9	696.4	48296.8	721.4	48229.8	746.4
		14	47010.5	597.4	46943.9	622.3	46877.3	647.3	46810.6	672.3	46743.9	697.3
		15	45523.0	548.6	45456.8	573.5	45390.6	598.5	45324.3	623.5	45258.0	648.5
		16	44035.5	500.1	43969.7	525.0	43904.0	550.0	43838.0	575.0	43772.1	600.0
		17	42548.0	451.9	42482.6	476.8	42417.2	501.8	42351.7	526.8	42286.2	551.8
		18	41060.5	404.1	40995.4	429.0	40930.4	454.0	40865.4	479.0	40800.3	504.0
		19	39573.0	356.5	39508.3	381.4	39443.7	406.4	39379.1	431.4	39314.4	456.4
		20	1238085.5	2297309.1	1238021.2	2299334.1	1237957.0	2301359.1	1237892.8	2303384.0	1237828.5	2305409.0
		21	36597.9	262.1	36534.0	287.1	36470.2	312.1	36406.4	337.0	36342.5	362.0
		22	35110.4	215.5	35046.9	240.4	34983.5	265.3	34920.1	290.3	34856.6	315.4
		23	33622.8	169.0	33559.7	193.9	33496.7	218.9	33433.7	243.9	33370.6	268.9
		24	32135.3	123.7	32072.6	148.7	32010.0	173.7	31947.4	198.6	31884.7	223.6
		25	30647.7	077.1	30585.4	102.0	30523.2	126.9	30461.0	151.9	30398.7	177.0
		26	29160.1	2297031.5	29098.2	056.5	29036.4	081.5	28974.6	106.4	28912.7	131.4
		27	27672.5	2296986.5	27611.0	2299011.2	27549.6	2301036.1	27488.2	061.1	27426.7	086.2
		28	26184.9	941.3	26123.8	2298966.3	26062.8	2300991.3	26001.8	2303016.2	25940.7	2305041.2
		29	1224697.3	2296896.7	1224636.6	2298921.7	1224576.0	2300946.6	1224515.4	2302971.5	1224454.7	2304996.6

FIG. 4

(ILLUSTRATIVE TABLE)

2308

FIRE CONTROL ZONES

Designation	Central Meridian	Limiting Meridians
A	73	68° 30′ - 77° 30′
B	81	76° 30′ - 85° 30′
C	89	84° 30′ - 93° 30′
D	97	92° 30′ - 101° 30′
E	105	100° 30′ - 109° 30′
F	113	108° 30′ - 117° 30′
G	121	116° 30′ - 125° 30′

The only exception so far as limiting meridians are concerned, is the strip over Maine to the eastward of longitude 68° 30′, which is included in the grid tables for Zone A, though it is more than 4° 30′ to the eastward of the central meridian of the zone.

The zones are shown graphically in illustration No. 1.

The one hundred thousand grid lines are shown for Zone C in illustration No. 2.

Designation of Special Military Maps

It is necessary that each special military map be given the letter of the zone within which it falls. Immediately following the letter should be given the coordinates of the southwest corner of the map. As the maps are all of the same size, which is 10,000 yards East and West and 6,000 yards North and South it will not be necessary to give the entire X and Y coordinates of the corner of the map. They can be abbreviated by omitting the last three figures of the X and Y coordinates. For instance if in the first zone the X coordinates of the southwest corner of a fire control map is 1,160,000 and the Y coordinate is 2,292,000 the designation of the map will be A 1160.2292.

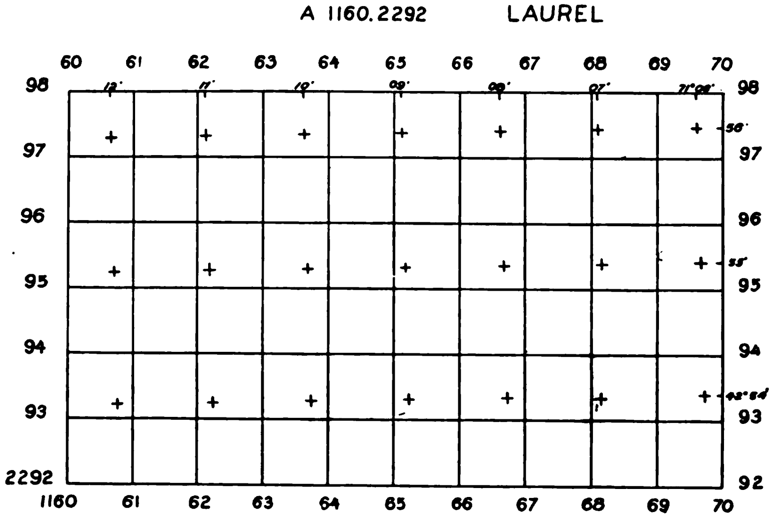


FIG. 5

(ILLUSTRATIVE)

2300

In addition to the designation by letters and numbers each fire control map must be given a name. This name should be that of some conspicuous topographic feature within the area covered by the map, such as a village, stream, hill, cross road, or some other object which is locally well known. If within the map there is no such feature which has a name it will be necessary to select a name arbitrarily. There must be no duplication of names of maps within a state.

The designation of the map with its name should be placed in the upper right hand corner as shown in illustration No. 5. The grid lines should be numbered as shown there. They will be placed on all edges of the map, while the geographical projection lines will be numbered at the top and on the right.

System of Laying Out Special Military Maps

With a grid system covering the greater portion of the Atlantic Coast a series of special military maps can be laid out in such a way that mapping can be started at a number of places with the assurance that when any two surveys are joined there will not be any overlaps, gaps, or offsets in the various maps. In order that this might be accomplished, it is necessary to adopt some simple system of laying out the special military maps. The one adopted is to have the X coordinates of East and West limiting grid lines on such a map multiples of 10,000 yards, and the Y coordinates of the North and South limiting grid lines of the special military maps multiples of 6000 yards. The coordinates to be considered in determining these multiples are those beginning at the origin of coordinates and not the coordinates of the intersection of the 73rd meridian and parallel 40° 30′.

It will be necessary to have the grid system superimposed upon one or more small scale maps covering the area to be surveyed and mapped in order that the relation of the topography shown on the small scale maps, to the special military maps may be known. For instance, if it were necessary to make special military maps covering Hampton Roads, it would be desirable to have those maps shown on some small scale chart of the U. S. Coast and Geodetic Survey of the lower Chesapeake Bay or a small scale map of the U. S. Geological Survey covering the region in question. With the special military maps laid out on the small scale map, the field work can then be done for any particular area desired. It is not necessary that the plotting of the special military maps on the other maps should be done with extreme accuracy. It is simply a guide for the field operations.

Use of Tables

As has been stated above, nearly the whole East coast of the United States will be covered by tables which give the relation between spherical coordinates and grid coordinates. The grid coordinates are expressed in yards. The table shows the grid coordinates in yards of the intersection of each minute of longitude with each minute of latitude within the whole area covered by the grid system.

The Special military maps which are to be based on the grid system are to be 10,000 yards long in an east and west direction and 6000 yards deep in a north and south direction.

The grid system is placed on the field sheets and final maps as even thousand yard lines.

THE KILOMETRIC GRID

The grid tables computed in yards can be used to place a kilometric grid on a map. This can be done by converting to meters the yard coordinates of one of the thousand yard intersections on the map. With these meter coordinates points can be plotted which will have values to even kilometers. Through these points kilometer grid lines will be drawn parallel to the regular yard grid lines. For instance, if the X and Y coordinates converted to meters had values at the southwest corner of the map of 953,624, and 1,242,719 respectively then the first north and south kilometer grid line would be 376 meters east of the corner and the first east and west kilometer grid line would be 281 meters north of the corner. After these two points of the kilometric system have been found north and south and east and west lines can be drawn through them parallel to the thousand yard grid lines. After two kilometric grid lines have been placed upon the map the whole map can easily be covered by the kilometric grid system. This is done by simply plotting along the east and west line distance of 1, 2, 3, etc., kilometers from the north and south kilometer grid line. Similarly the east and west kilometer grid line can be laid off on the north and south line.

If the map has been at all distorted since the yard grid was placed upon it, it would be well to convert the coordinates of several of the one thousand yard grid intersections into meters and the intermediate grid lines of kilometric system can then be interpolated. In this way the effect of any distortion of the map is minimized.

METHOD OF PLACING THE SPHERICAL PROJECTION ON SPECIAL MILITARY MAPS

Let it be supposed that a series of special military maps have been laid out on a small scale map covering the area to be surveyed and that it is desired to place the spherical coordinates on a special military map on which the thousand yard grid lines have been drawn.

From the small scale map some intersection of a minute of latitude and a minute of longitude is selected which falls within the special military map in question.

The tables are entered for that particular longitude and latitude and the X and Y coordinates are found. The difference between the X coordinates of the intersection and the

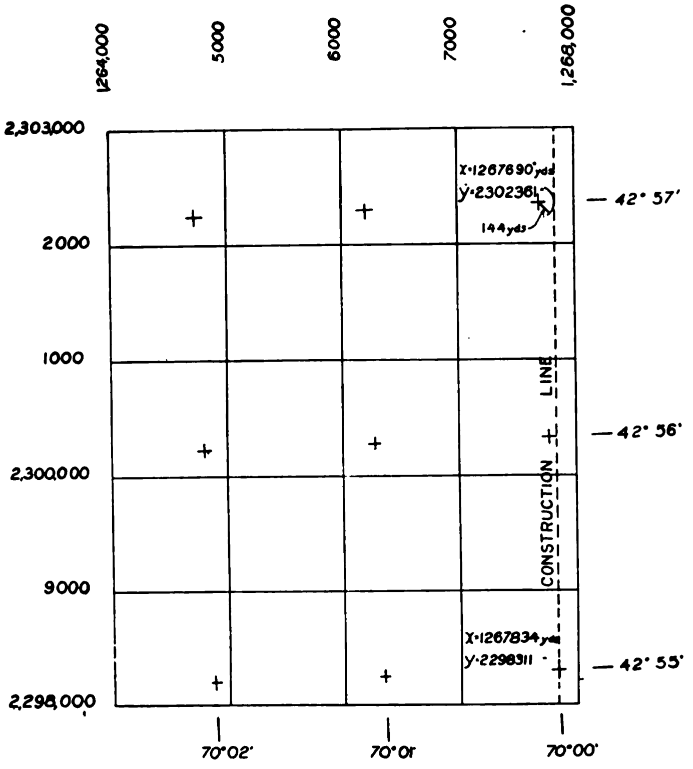


FIG. 7 2310

thousand yard north and south grid line just to the westward of the intersection is laid off to the eastward of that thousand yard grid line. Likewise the difference between the Y coordinate for the intersection of the minute of latitude and longitude and of the Y coordinate of the even thousand yard east and west grid line just to the south of it will be the distance to be plotted to the north of that grid line. These two differences in the X and Y coordinates will locate accurately, on the grid system of the special military map the particular intersection of the minute in longitude and latitude. In a similar manner all the other intersections of minutes of latitude and longitude coming within the area of any special military map can be plotted.

In illustration No. 7, let it be supposed that the grid system is already on the map as shown and that it is desired to put spherical coordinates on the same sheet in the proper relation to the grid. An inspection of the tables shows that the intersection of 42° 55′ of latitude with 70° of longitude falls in the lower right hand corner of the sheet. The coordinates of this intersection are x = 1,267,834 yards and Y = 2,298,311 yards. The position of this intersection can be obtained by plotting 834 yards east of the grid line 1,267,000 and 311 yards north of the grid line 2,298,000.

After the one intersection of a minute of latitude and a minute of longitude has been plotted on the sheet, it is a simple matter to continue the plotting of all other minute intersections within the area covered by the sheet.

TABLE OF CORRECTIONS TO BE APPLIED TO Y VALUES GIVEN IN YARDS PER THOUSAND YARDS
TOP ARGUMENT IS DISTANCE IN DEGREES OF LONGITUDE FROM CENTRAL MERIDIAN.
SIDE ARGUMENT IS LATITUDE.

	0° 00'	1° 30'	1° 00'	1° 30'	2° 00'	2° 30'	3° 00'	3° 30'	4° 00'	4° 30'	5° 00'	5° 30'	6° 00'	6° 30'
24°	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.6	2.0	2.6				
26	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5				
28	0.0	0.0	0.1	0.3	0.5	0.7	1.1	1.5	1.9	2.4				
30	0.0	0.0	0.1	0.3	0.5	0.7	1.0	1.4	1.8	2.3				
32	0.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.8	2.2				
34	0.0	0.0	0.1	0.2	0.4	0.7	0.9	1.3	1.7	2.1				
36	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0				
38	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5	1.9				
40	0.0	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8				
42	0.0	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.3	1.7				
44	0.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0	2.4	2.8	3.3
46	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.8	2.2	2.6	3.1
48	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.1	2.5	
50	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.3				

FIG. 6 2311

(ILLUSTRATIVE TABLE)

METHOD OF PLACING GRID SYSTEM ON A MAP HAVING SPHERICAL PROJECTION

If it is desired to put the grid system on a map which already has the polyconic system of projection, the operation will be as follows: Take some one intersection of a meridian and parallel in one corner of the map and enter the grid tables with these values and obtain the X coordinate for that intersection. Next take an intersection of the same meridian with a much higher or lower latitude. For instance, if the first intersection was in the southeast corner of the map, then take an intersection in the northeast corner, if the map is square with the meridians and parallels. Obtain from the the table the X coordinate for this northeast intersection. Next take the difference between the X coordinates of these two intersections and with this as a radius describe an arc of a circle around one of the intersections (say the N.E. one). This should be to the westward of the point, if the longitude is greater than 73° and to the eastward if less than 73°. After this arc has been drawn, place a straight-edge on the other intersection of the meridian and parallel and tangent to the arc and draw a line across the map. This line will be parallel to the grid system and upon it can be constructed the grid system of the map.

Let it be supposed that in illustration No. 7 the spherical coordinates have been plotted and that it is later desired to super impose the grid coordinate. In this case the table should be entered and the X and Y coordinates obtained for the intersections of 42° 55′ of latitude with 70° 00′ of longitude and for 42° 57′ of latitude with 70° 00′ of longitude. The tables show a difference in the X coordinates for these two intersections of 144 yards. With this distance as a radius, an arc of a circle is described to the eastward of the more northern one of the two intersections. (This arc could have been described to the westward of the southern one of the two intersections). Next draw a line through the lower minute intersection tangent to the arc of the circle which was drawn to the eastward of the upper minute intersection. This line is parallel to a north and south line of the grid and may be considered a construction line. The next operation is to lay off a distance of 834 yards to the westward and at right angles to the construction line at the lower part of the sheet and the same distance to the westward of the construction line at the upper part of the sheet. A line joining the two points thus laid off will be a north and south 1000 yard line of the grid system whose X coordinate is 1,267,000 yards.

The next operation would be to lay off the distance of 311 yards along the construction line to the southward of the intersection of 42° 55′ latitude with 70° 00′ of longitude. The point thus plotted will be an even 1000 yard grid line running east and west. This point can be transferred to the north and south grid line previously constructed by drawing a line through it at right angles to the construction line or to the north and south grid line.

If the map is true to scale and not distorted, the grid system can now be extended over the whole sheet, but it is probable that the scale of the map will be somewhat changed from weather conditions and there may be some distortion in the sheet. This being the case, it will be well to lay off a point on the grid system near each of the four corners of the map and the intermediate 1000 yard grid lines running both north and south and east and west can be interpolated and thus the effect of any error in the scale in the map and distortion may be minimized or eliminated.

PLANE TABLE SHEETS

The plane table will be used for the location of the topographic features of the earth's surface. On the plane table is placed a sheet of paper on which the control points have been plotted. In order that these control points may be shown in the proper relation to each other, it is necessary to have some lines on the sheet which will represent some system of projection. In all of the special military surveys the polyconic projection will be used on the plane table sheets and each sheet will have a separate projection laid out upon it. There will be no relation between the projection shown on the single plane table sheet and the general polyconic projection for the whole area of a zone.

When a plane table sheet has a local polyconic projection placed upon it and also has the general grid system of coordinates on it, theoretically the grid lines will not be straight. The deviation of the grid lines from a straight line, under this condition, will be so slight at any place within the whole zone covered by the grid system that no error will result. In fact, the deviation of the grid line from a straight line will always be within the amount of distortion of the paper due to weather conditions.

The method of laying out the polyconic projection is described in detail and the necessary tables are given in Special Publication No. 5 of the U.S. Coast and Geodetic Survey. Briefly, the process of making a polyconic projection on a plane table sheet is to lay out the central meridian as a straight line and then enter the tables in Special Publication No. 5

and plot the intersections of minutes of latitude with minutes of longitude by means of the X and Y coordinates given therein.

CONTROL POINTS ON PLANE TABLE SHEETS

When the plane table sheet has been prepared by having the projection placed upon it, the next operation will be to have the control points of the triangulation and tape traverse plotted upon the sheet in their true geographic positions. These points will be used for the control of the topographic work in the field.

DETERMINATION OF DISTANCE BETWEEN POINTS FROM THEIR GRID COORDINATES

The distance between two points whose grid coordinates are given is equal to the square root of the sum of the squares of the difference in the X coordinates and of the Y coordinates. This distance will be true over the whole map for lines running east and west. It will be within one part in one thousand for lines running in any direction if within 3° of the central meridian. Beyond that limit the error in a north and south line will increase until it is about one and one-half parts in one thousand at a distance of 4° 30′ from the central meridian.

If an accurate distance is desired it may be obtained from the differences in the X and Y coordinates if to the Y difference is applied the scale correction.

These corrections are shown in the accompanying table.

The uncorrected grid distance is always greater than the true or ground distance.

TRANSFORMATION OF GEOGRAPHIC AZIMUTHS TO GRID AZIMUTHS

Owing to the converging of meridians, any line on the earth's surface will make a different angle with the grid meridian from the angle it makes with the geographic meridian.

In order to determine easily the difference between the two azimuths, tables have been prepared from which the correction may be computed, (Figures 8 and 9).

The following is an example of the computation of the difference between the geographic and grid azimuths.

Let it be desired to determine the difference between the geographic and grid azimuth at a point whose latitude is 42° 50′ and longitude 70° 18′. In the azimuth tables it is found that the azimuth correction for 42° latitude and 70° longitude is 2° 00′ 24.8″ and the correction for the same latitude and longitude 71° is 1° 20′ 17.2″. The difference between these two corrections is 40′ 07.6″. The point for which the correction is desired is in longitude 70° 18′, which may be expressed as 70.30°. The difference mentioned above multiplied by .30 is 12′ 02.3″. This subtracted from 2° 00′ 24.8″, which is the correction for latitude 42° and longitude 70°, gives 1° 48′ 22.5″. It is similarly found that the correction for latitude 43° and longitude 70° 18′ is 1° 50′ 27.6″.

The difference between these two corrections for longitude 70° 18′ is 2′ 05.1″. Latitude 42° 50′ may be expressed decimally as 42.83°. The difference between the two corrections multiplied by .83 is 1′ 43.8″. If this is added to 1° 48′ 22.5″ the correction at 70° 18′ of longitude and 42° of latitude, the result will be 1° 50′ 06.3″, which is the difference between the grid and the geographic azimuths at a point whose latitude is 42° 50′ and longitude 70° 18′.

To the west of the central meridian of the polyconic projection on which is superimposed the grid system the grid azimuths counted clockwise will be larger than the geographic or spherical azimuths, therefore, when azimuths are reckoned clockwise the difference between the two kinds of azimuths as computed from the table must be added to the geographic azimuth to obtain the grid azimuth and to the eastward of the 73° of longitude the difference between the geographic and grid azimuths as computed from the tables, must be subtracted from the geographic azimuth in order to obtain the grid azimuth.

The tables for the special military maps apply to the whole country, therefore the azimuth tables can be used to obtain the difference between a geographic and grid azimuth at any place in the United States.

The azimuth tables are extended to cover that portion of Maine to the eastward of the 68° 30′ of longitude.

Care must be taken to avoid applying the azimuth correction computed for one zone to an azimuth located in an adjoining zone.

TRANSFORMATION OF GRID AZIMUTHS TO SPHERICAL AZIMUTHS

The azimuth correction tables are used in computing the difference between a grid azimuth and a geographic azimuth.

TABLE FOR THE REDUCTION OF GEODETIC AZIMUTHS TO GRID AZIMUTHS

	Long. 67°			Long. 68°			Long. 69°			Long. 70°			Long. 71°			Long. 72°			Long. 73°		
					76			77			78			79			80			81	
					84			85			86			87			88			89	
					92			93			94			95			96			97	
					100			101			102			103			104			105	
					108			109			110			111			112			113	
					116			117			118			119			120			121	
°				°	'	"	°	'	"	°	'	"	°	'	"	°	'	"	°	'	"
24				2	01	55	1	37	33	1	13	11	0	48	48	0	34	34	0	00	00
25					06	30		41	22		16	03		50	42		25	21			00
26					11	25		45	08		18	53		52	36		26	18			00
27					16	04		48	53		21	41		54	28		27	14			00
28					20	42		52	36		24	28		56	20		28	10			00
29					25	18		56	17		27	14		58	10		29	05			00
30					29	51		59	56		29	58		59	59		30	00			00
31					34	22	2	03	32		32	40	1	01	48		30	54			00
32					38	50		07	06		35	21		03	35		31	48			00
33					43	15		10	38		38	00		05	21		32	41			00
34					47	37		14	08		40	37		07	06		33	33			00
35					51	56		17	35		43	13		08	49		34	25			00
36					56	11		21	00		45	46		10	31		35	16			00
37				3	00	24		24	22		48	18		12	12		36	06			00
38					04	33		27	41		50	47		13	52		36	56			00
39					08	39		30	58		53	15		15	30		37	45			00
40					12	42		34	12		55	40		17	07		38	34			00
41					16	40		37	23		58	04		18	43		39	22			00
42					20	36		40	31	2	00	25		20	17		40	09			08
43					24	28		43	36		02	44		21	50		40	55			00
44	4	09	50		28	15		46	39		05	00		23	21		41	41			00
45		14	19		32	00		49	38		07	15		24	51		42	25			00
46		18	46		35	40		52	34		09	27		26	19		43	10			90
47		23	04		39	17		55	27		11	37		27	46		43	53			00
48		27	19		42	49		58	17		13	44		29	10		44	36			00
49					46	17	3	01	04		15	49		30	33		45	17			00
50					49	12		03	47		17	52		31	54		45	58			00

FIG. 8

(ILLUSTRATIVE TABLE)

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Table Value in Degrees $= \lambda \sin \varphi - 1/12\, \lambda^3 \left(\frac{\pi}{180}\right)^2 \sin 2\varphi^* \cos \varphi.$

TABLE FOR THE REDUCTION OF GEODETIC AZIMUTHS TO GRID AZIMUTHS

	Long. 73°			Long. 74°			Long. 75°			Long. 76°			Long. 77°			Long. 78°		
		81			82			83			84			85			86	
		89			90			91			92			93			94	
		97			98			99			100			101			102	
		105			106			107			108			109			110	
		113			114			115			116			117			118	
		121			122			123			124			125			126	
Lat. °	°	'	"	°	'	"	°	'	"	°	'	"	°	'	"	°	'	"
24	0	00	00	0	34	34	0	48	48	1	13	11	1	37	33	2	01	55
25			00		25	21		50	42		16	03		41	22		06	30
26			00		26	18		52	36		18	53		45	08		11	25
27			00		27	14		54	28		21	41		48	53		16	04
28			00		28	10		56	20		24	28		52	36		20	42
29			00		29	05		58	10		27	14		56	17		25	18
30			00		30	00		59	59		29	58		59	56		29	51
31			00		30	54	1	01	48		32	40	2	03	32		34	22
32			30		31	48		03	35		35	21		07	06		38	50
33			00		32	41		05	21		38	00		10	38		43	15
34			00		33	33		07	06		40	37		14	08		47	37
35			00		34	25		08	49		43	13		17	35		51	56
36			00		35	16		10	31		45	46		21	00		56	11
37			00		36	06		12	12		48	18		24	22	3	00	24
38			00		36	56		13	52		50	47		27	41		04	33
39			00		37	45		15	30		53	15		30	58		08	39
40			00		38	34		17	07		55	40		34	12		12	42
41			00		39	22		18	43		58	04		37	23		16	40
42			00		40	09		20	17	2	00	25		40	31		20	36
43			00		40	55		21	50		02	44		43	36		24	28
44			00		41	41		23	21		05	00		46	39		28	16
45			00		42	25		24	51		07	15		49	38		32	00
46			00		43	10		26	19		09	27		52	34		35	40
47			00		43	53		27	46		11	37		55	27		39	17
48			00		44	36		29	10		13	44		58	17		42	49
49			00		45	17		30	33		15	49	3	01	04		46	17
50			00		45	58		31	54		17	52		03	47		49	52

FIG. 9

(ILLUSTRATIVE TABLE)

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*The second term is small, being at 6° from central meridian and lat 45 but 1 4″. It may therefore be neglected in firing.

The spherical coordinates of the grid station may be scaled from the map or may be computed. Where the spherical coordinates are known the tables are used in the same manner as that described under the heading "Transformation of Geographic to Grid Azimuths," but when the azimuths are reckoned clockwise the difference will be added when to the east of the central meridian and subtracted when to the westward. Note especially the caution in the last paragraph under the preceding heading.

TRANSFORMATION OF SPHERICAL TO GRID AZIMUTHS AND THE REVERSE APPROXIMATE METHOD

When only an approximate difference between the grid and spherical azimuths is needed, it may be computed from the X and Y coordinates given in the grid tables.

The process would be to take the difference between the X coordinate of the nearest intersection of one minute of longitude and latitude and the X coordinate of an intersection of a higher latitude with the same minute of longitude and divide this difference by the difference in the Y coordinates of the two intersections. The quotient would be the tangent of the angle between a grid meridian and a geographic meridian. For instance, the difference in the Y coordinates of the intersections of 70° 00′ with 42° 55′ and 42° 59′ is 8100 yards. The difference in the X coordinates is 289.0 yards. The X difference divided by the Y difference wouldbe .03568. This is the natural tangent of 2° 02′ 40″.

This angle is added to or subtracted from the spherical azimuth to obtain the grid azimuth or is applied to the grid azimuth to obtain the spherical azimuth. In this particular case it must be subtracted from the spherical azimuth to get the grid azimuth.

The difference will be correct within one-half minute in all cases.

TRANSFORMATION OF SPHERICAL TO GRID COORDINATES

Let P represent latitude
Let L represent longitude
Let C be the station
Let A be point on first full minute to the west of C of same latitude as C

Let B be point on first full minute to the east of C of same latitude as C

Let X_1 and Y_1 be grid coordinates of minute intersection S.W. of C

Let X_2 and Y_2 be grid coordinates of minute intersection N.W. of C

Let X_3 and Y_3 be grid coordinates of minute intersection N.E. of C

Let X_4 and Y_4 be grid coordinates of minute intersection S.E. of C

Let C_P = seconds of latitude of C divided by 60

Let C_L = seconds of longitude of C divided by 60

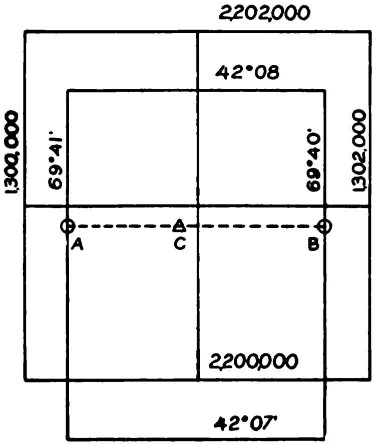

FIG. 10

3314

Then we have the following equations:

Grid X coordinate of A = $X_a = X_1 + C_P(X_2 - X_1)$

Grid X cordinate of B = $X_b = X_4 + C_P(X_3 - X_4)$

Grid X coordinate of C = $X_c = X_b + C_L(X_a - X_b)$

Grid Y coordinate of A = $Y_a = Y_1 + C_P(Y_2 - Y_1)$

Grid Y coordinate of B = $Y_b = Y_4 + C_P(Y_3 - Y_4)$

Grid Y coordinate of C = $Y_c = Y_b + C_L(Y_a - Y_b)$

Computation of Artillery Grid Coordinates from Spherical Coordinates

No.	Station	Browne
1	P	40° 50′ 30.73″
2	C_P	.512
3	L	73° 47′ 12.57″
4	C_L	.210
5	X_1	926205.3
6	X_2	926223.8
7	X_3	927760.8
8	X_4	927742.7
9	X_2-X_1	18.5
10	X_3-X_4	18.1
11	$C_P(X_2-X_1)$	9.5
12	$C_P(X_3-X_4)$	9.3
13	$X_a=X_1+(11)$	926214.8
14	$X_b=X_4+(12)$	927752.0
15	X_a-X_b	−1537.2
16	$X=X_b+(4)\times(15)$	927429.2
17	Y_1	2040817.5
18	Y_2	2042841.6
19	Y_3	2042827.7
20	Y_4	2040803.6
21	Y_2-Y_1	2024.1
22	Y_3-Y_4	2024.1
23	$C_P(Y_2-Y_1)$	1036.3
24	$C_P(Y_3-Y_4)$	1036.3
25	$Y_a=Y_1+(23)$	2041853.8
26	$Y_b=Y_4+(24)$	2041839.9
27	Y_a-Y_b	13.9
28	$Y=Y_b+(4)\times(27)$	2041842.8

Transformation of Grid to Spherical Coordinates

In the accompanying figure let 1-2-3-4 be a quadrangle of minute intersections within which the given point, P, lies.

Let X, Y be the grid coordinates of P.

Let X_1, X_2, X_3, and X_4 be the X coordinates of the corners 1,2,3, and 4 respectively.

Let Y_1, Y_2, Y_3, and Y_4 be the Y coordinates of the corners 1,2,3, and 4 respectively.

A, B, C, and D are points at which grid lines through P intersect the lines of the minute quadrangle.

Let X_a, X_b, X_c, X_d, Y_a, Y_b, Y_c, and Y_d be the grid coordinates of the points A, B, C, and D.

Then $$Y_a = Y_4 + \frac{X_4 - X}{X_4 - X_1}(Y - Y_4)$$

$$Y_c = Y_3 + \frac{X_3 - X}{X_3 - X_2}(Y_2 - Y_3)$$

Then the seconds of latitude of P above the minute line 1 - 4 will be:

$$\text{Seconds in latitude} = 60''\left(\frac{Y - Y_a}{Y_c - Y_a}\right)$$

$$X_b = X_1 + \frac{Y - Y_1}{Y_2 - Y_1}(X_2 - X_1)$$

$$X_d = X_4 + \frac{Y - Y_4}{Y_3 - Y_4}(X_3 - X_4)$$

Then the seconds of longitude of P west of the minute line 3 - 4 will be:

$$\text{Seconds in longitude} = 60''\left(\frac{X_d - X}{X_d - X_b}\right)$$

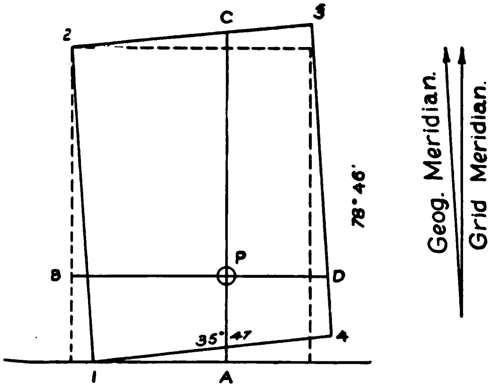

FIG. 11

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The computation can best be made on a form similar to the following sample. The grid coordinates of the point P are known while the grid coordinates of the four minute intersections are obtained from the grid tables. Care should be taken regarding the signs of differences shown in the form.

Transformation of Grid to Spherical Coordinates

Project: Raleigh State: North Carolina

Name of Station: Cary Coordinates are given in yards.

1	Lat. Min. to South	35° 47′
2	Long. Min. to East	78° 46′
3	X	1220027.5
4	Y	1430414.5
5	X_1	1219154.9
6	X_2	1219109.2
7	X_3	1220756.3
8	X_4	1220802.4
9	Y_1	1429935.3
10	Y_2	1431958.1
11	Y_3	1431995.5
12	Y_4	1429972.7
13	X_4-X	774.9
14	X_4-X_1	1647.5
15	Y_1-Y_4	−37.4
16	$Y_A=(12)+\left(\frac{13}{14}\right)(15)$	1429955.1
17	X_3-X	728.8
18	X_3-X_2	1647.1
19	Y_2-Y_3	−37.4
20	$Y_C=(11)+\left(\frac{12}{18}\right)(19)$	1431979.0
21	$Y-Y_A$	459.4
22	Y_C-Y_A	2023.9
23	Sec. Lat. $= 60'' \left(\frac{21}{22}\right)$	13.62″
24	$Y-Y_1$	479.2
25	Y_2-Y_1	2022.8
26	X_2-X_1	−45.7
27	$X_B=(5)+\left(\frac{24}{25}\right)(26)$	1219144.1

28	$Y - Y_4$	441.8
29	$Y_3 - Y_4$	2022.8
30	$X_3 - X_4$	−46.1
31	$X_D = (8) + \left(\frac{28}{29}\right)(30)$	1220792.3
32	$X_D - X$	764.8
33	$X_D - X_B$	1648.2
34	Sec. Long. $= 60'' \left(\frac{32}{33}\right)$	27.84″
35	Lat. = (1)+(23)	35° 47′ 13.62″
36	Long. = (2)+(34)	78° 46′ 27.84″

NOTE.—The numbers inclosed in parenthesis in column 2 represent the values in column 3 opposite the corresponding numbers of column 1.

EDITORIAL REVIEWS

Identification of Ships

All navies are at the present time devoting considerable attention to the development of instantaneous recognition signals between ships at sea. In endeavoring to emphasize the value of recognition signals, which are as important to the Coast Artillery as to the Naval Service, it seems worth while to cite a few examples, occurring during the Great War, which indicated the lack of a reliable system.

Among the most important examples may be mentioned the pitiful and useless destruction of friendly submarines by Allied ships, not only by merchant ships, but by war vessels which, in the emergency conditions, found it necessary to protect themselves at the expense of their own countrymen. Then there is the case of the German cruiser *Emden* which boldly entered a British port and sank a Russian cruiser, the *Emden*, having been mistaken by the shore forces for a British ship. Again, there is the experience of the Italian motor boats in sinking the Austrian dreadnoughts at Pola, where the highspeed motor boats entered the harbor and made a successful surprise attack, because the Austrians were not sufficiently watchful. Another example of failure in recognition is furnished by the German raiders, and as an amusing incident, may be mentioned the ruse in which the captain, dressed in feminine clothes, stalked up and down the quarter-deck, underneath a hot sun and a parasol, until the raider, unsuspected, approached a merchant ship and sank it in a few moments. Here it is evident that the use of a proper demand signal might have permitted the merchant ship to have used her own guns in time to have saved herself. Then, there is the experience of the Turkish destroyer at the Dardanelles, which ran the straits at night, under the protection of the darker shore, and, attacking the British squadron at anchor below the straits, sank one of the ships by torpedo, and returned to her base uninjured. For another example, recall the disastrous experience which occurred in the North

Sea, where the Allied destroyers fired upon each other because of the difficulty which arose in recognition under conditions of low visibility, which rendered sight recogniton an impossibility. As a last, but a most important example, there is the attack of the British on Zeebrugge, which exemplifies the imperative necessity of immediate recognition, for in this case each minute's delay was of the greatest importance in its bearing on repelling the attacking ships.

The recognition and identification of ships is of great importance to the Coast Artillery. There is probably adequate equipment in each Coast Artillery fort for giving suitable instruction to the commissioned and noncommissioned personnel in recognizing foreign ships. This equipment consists of lantern slides and projecting machines furnished as a part of the Coast Artillery War Game, and should be used to give instruction in ship recognition. In addition to the use of lantern slides, much can be accomplished with models. Some forts now have a supply of these, and those that have none can readily improvise them. By the use of models, observers can be trained to recognize ships approaching at various angles. In sight recognition, much stress should be placed on instruction using models, for it is seldom that a vessel will be seen approaching as shown in a silhouette. Of course silhouettes are useful and should be provided for all foreign ships, as an adjunct to "Jane's Fighting Ships." The personnel could then be instructed in ship recognition, making use of lantern slides, silhouettes, models, and any other devices, so as to make them familiar with not only ships of our own navy, but those of foreign navies. In this connection it must be remembered that many ships are likely to be camouflaged so effectively as to cause any method of recognition by sight to fail. There is evidently an absolute necessity for developing some system of shore-ship signals that will provide for instantaneous recognition by methods of visual signals, radio, sound, including oscillators and hydro-phones, and special visual appliances.

This whole problem is surrounded with perplexing difficulties, which have by no means been solved, and until the problem is solved, remains a worthy challenge to the talents and concentration of the Coast Artillery officer.

* * *

The Coast Artillery and the Colleges

Every Coast Artillery officer should be sure to read in the 5th April number of LIAISON the article on the "Proposed Course of Instruction for Coast Artillery Units of the R.O. T.C." Briefly, this course is based on the principle of utilizing the academic courses given at any college, either as they stand, or slightly modified to meet the requirements of an officer's training, rather than give all specific training in Coast Artillery technique by separate courses. Due credit will be given for courses in English, one other modern language, American and General History and Civics, which will be required. All such instruction and the modified courses in mathematics and physics, will be given by the college faculty, while courses in Gunnery and Theoretical Military Instruction will be given by the army officer on duty. A distinctive feature of the course is that neither drills nor wearing of uniforms will be required during the academic year, and that all such practical military instruction will be consolidated into two or three training camps of six weeks, during the summer vacations.

To anyone who has known the relations of the colleges and the army in former years and who also realizes the tremendous asset that college men have proven to the Coast Artillery in its task in the world war, there will be refreshingly apparent the revolutionary progress involved in the conception of this new scheme.

As a practical proposition, the army will secure the most hearty following from college students undergoing military instruction when the conditions are such that the military instruction conforms most to their college scheme of existence. For the time being, college life with its work and play is an absorbing chapter to the student which he resents having interrupted by the routine of drills in uniform, which at the moment are distasteful to him as they need not be at other periods of his life, simply because military drill snatches him out of a very distinctive atmosphere, and robs him of the sensation of picturesque individualism which in all his other relations on the campus he keenly feels and enjoys. So one merit of this scheme of instruction is that it provides the possibility for all practical military instruction to be consolidated into summer training camps.

But the real step forward is the recognition of the validity of academic standards and the elastic adaptation of regular courses in college curricula to meet the needs in the training of Coast Artillery officers. The direct application of theory in certain courses to its practical adaptation in certain Coast Artillery matériel, constitutes a valuable help in confirming in the student's mind the academic principle which is the professor's immediate concern, and at the same time a Coast Artilleryman is in the making.

The warmest mutual sympathy and co-operation between the Coast Artillery and the colleges is necessary to spell the advantage that each can be to the other. Let us be frank enough to admit that the greater immediate advantage is forthcoming to the Coast Artillery, while in the last analysis the benefit will come home to the country, which both the Coast Artillery and the colleges seek to serve.

* * *

The Anti-Aircraft Service

During the last six months of the European War the fight for supremacy of the air was vigorously pushed by all of our Allies as well as by the Central Powers. Without entering into a dispute as to who did have the supremacy at various times we must admit that the Hun held his place in the air until the very last break came about November 4. In fact, you can hear from any number of Infantry or Artillery officers a statement like this: "The Boche had the air all to himself in our part of the line."

Fighting in the air and from the air are forms of modern warfare that have come to stay. In the wars of the future the belligerent who has kept up his aerial preparations and can immediately begin hostilities with the supremacy of the air will have a tremendous advantage. Assuming that we are now at peace we must begin to prepare not for another war but against another war. The surest way to keep some war-maker from picking a quarrel with us is to show him that we are prepared to meet any thrust which he may make. Then the problem of our General Staff is to keep in touch with the military progress of all possible belligerents of the future and to develop correspondingly our own military power so as to discourage all their efforts toward war.

In making these peace time plans against future wars, the General Staff should from time to time make an estimate of the situation just as a commander in the field must continually make an estimate of the situation in order to dispose his forces for the various phases of the battle. According to the principles of tactics one of the important things to consider in making an estimate of the situation is: what will the enemy do; what are his intentions? And after finding out the enemy's intentions the tactical commander makes his dispositions accordingly. Now since we know one of the moves which our enemy of the future will make, isn't it logical that we should now prepare a defense for it? What defense are we to prepare against an enemy's tremendous effort in the air? This form of warfare consists in bombing cities, railroad yards, supply depots, etc., bombing and machine gun fire upon troops in the front line and on the march. One form of defense against these attacks will be to combat them with our own air forces. But this must be assisted and under certain conditions entirely replaced by a well organized defense from the ground. This ground defense system constitutes the Anti-aircraft Service.

No matter how well organized and trained our air forces are they alone cannot constitute a complete defense against enemy aerial warfare any more than infantry, unaided by other arms, can meet all the assaults of the enemy infantry. When the Germans introduced a new form of warfare at Ypres in April, 1915, by liberating a cloud of chlorine gas against the Canadians, the British immediately began preparing against a repetition of such an attack. Their defense did not consist only in liberating a cloud of gas to go over and neutralize the one coming from the enemy trenches, but they also equipped their men with gas masks and soon provided a very elaborate system of gas defense. Although the British had the most powerful fleet in the world, they were not content with this alone to protect them from enemy attacks from the sea, but in addition they kept their shore batteries fully manned and their harbors mined. Just as the infantry requires aid from other arms, just as gas attacks demand auxiliary defense, and just as an effective navy requires the assistance of shore batteries and mines, so does defense against enemy aerial warfare require well organized auxiliary defense from the ground—the Anti-aircraft Service.

Now to what extent are we to develop our Anti-aircraft Service? It is a problem for the Coast Artillery. During the war the personnel of the Anti-aircraft Service of the

A.E.F. was taken from the Coast Artillery. The opportunity is now ours, we can make of this service what we will.

◆ ◆ ◆

Stick by the Ship

The war is over. This fact either consciously or unconsciously, is in everybody's mind. To the professional soldier the fact brings a train of reactions which at first blush are depressing rather than stimulating. Some of the reactions are these:

(a) Wars come on an average but once in a generation, and now that this war is over, few in the Service may expect further opportunity for war experience.

(b) The country is tired of military life and all its ways, and may skimp and pare military expenditure to such an extent that progress may be throttled at the source.

(c) The natural American tendency toward political recrimination may crystallize into a spirit of bitter criticism of the army and all its works which perchance will consign the Regular Army to Coventry for a season.

Quite naturally many regular officers entertain a feeling of uncertainty and discouragement and a wonder whether the Service will continue to hold a challenge for their abilities and their best efforts. It is surely not too sweeping a statement to say that many are seriously thinking of resigning and entering upon business or professional careers. This feeling is enhanced by the positive stimulus to effort in the business world, which is already striping and grooming its entries in the new race for success.

The uncertainty regarding forthcoming legislation, coupled with the present shortage and shifting of enlisted personnel, induce a halting, negative attitude of mind. Undoubtedly we need the inspiration which will eventually come of an authoritative "All right, let's go!" and the apprisal of where we are to go.

In the meantime, until we receive such outward, positive stimulus, we have within the Service a source of inspiration which can tide over for every high-thinking officer this gray period and justify within him the conviction that it is worth while for him to stick by the Service, no matter what may happen. This inspiration should come from taking a new grasp on the meaning of a motto which has already meant much to the army—"Duty, Honor, Country." If this motto means anything, it means an inherent belief in the democracy for which we serve, and the love for that democracy which will hold us to the spirit of sacrifice of personal opportunity in peace if need be, that will match our common willingness to sacrifice life itself in time of war. Our country is not perfect, and has made mistakes, and can and may misunderstand us and the service to which we devote our lives. But whether the country knows it or not, we know that the country needs an army, and that for the army to be what the people need, it must hold the leaven of high-minded officers.

Now the inner meaning of *Duty* and *Honor* is *altruism.* There are now and always will be those who scoff at altruism as a practical guide for human effort. But the fact stands out that nearly all the biggest things in the world have been done in a spirit of altruism, by someone who either disregarded whether it paid or not or else recognized that it did not pay.

We have a right to work under conditions which will make our work effective and for which we will receive proper consideration—*by all means.* And in the long run the innate justice and common sense of the American people will insure that these conditions will prevail. But in the meantime, it is the duty and the honor of the professional soldier to steady the ark, and until the sailing is clear, to *stick by the ship.*

✦ ✦ ✦

MECHANICAL SPOTTING DEVICE*

By Major C. M. Burlingame, F.A.

1. This article furnishes *Description* and *Operation* of the Burlingame-Collet Spotting - Board, together with diagram of the same.

2. This board is submitted as a result of satisfactory trial and use in actual firing at Battery Selfridge, Fort Kamehameha, H.T.

3. The board is operated by one man, unassisted, and by its rapidity can easily take care of all splashes which are well enough separated to admit of independent consecutive observation through the sighting instruments.

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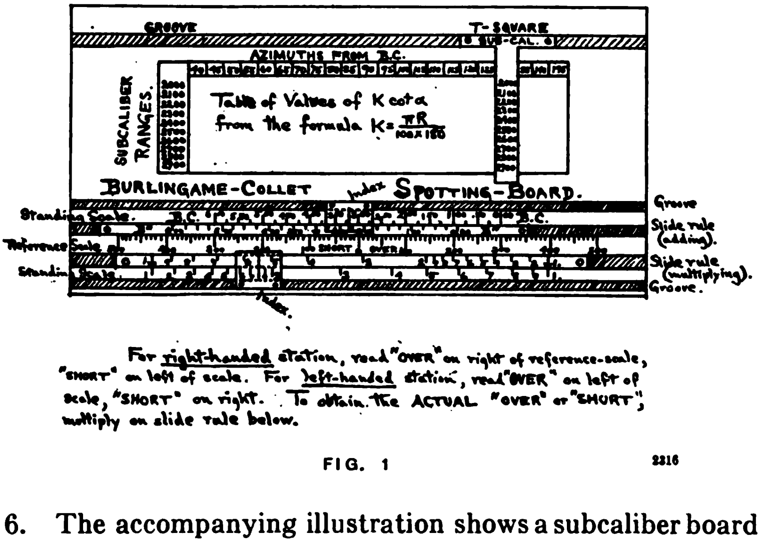
*"A model of this board modified so as to increase the accuracy and make the board universal has been constructed for test by the Coast Artillery Board."

4. The board is designed for values of the parallax "a" of the target with respect to the line BC-B″ which vary from 5 to 30 degrees. This makes it applicable to a very large number of batteries, by allowing the use of their secondaries as spotting stations.

5. For use at subcaliber practice, the best results are to be secured by computing an independent subcaliber table, and establishing an independent subcaliber spotting station at such a distance from BC that the angle "A" will approximate the probable service-practice angle. In case the subcaliber spotting-station is on that flank of the battery opposite the secondary, a separate board may be employed for subcaliber, the slide-rules of one board being arranged and labeled for right-handed spotting, those of the other for left-handed spotting.



The ranges shown are for a sub-caliber chart. For service-practice, this chart is replaced by a service chart. The azimuths shown are for a capital of 90°.

For right-handed station, read "OVER" on right of reference-scale, "SHORT" on left of scale. For left-handed station, read "OVER" on left of scale, "SHORT" on right. To obtain the ACTUAL "OVER" or "SHORT", multiply on slide rule below.

FIG. 1 2316

6. The accompanying illustration shows a subcaliber board labeled for a right-handed spotting station. The board is two feet wide by one foot high. Across the top is a groove for the range T-square. The latter extends downward six inches across the face of the "K cot a" table. The values of "K cot a" are best computed for each battery separately, as will be seen from the following formula:

"r equals d'cosec a plus d cot a."

In the formula "r" is the longitudinal deviation in yards, "d" and "d‴" are the lateral deviations from BC and B″ respectively, in yards. When "a" has a very small value, consider cosec a equal to cot a. Then we have the formula:

"r equals cot a times d plus d‴".

Letting R′ be the range, let K equal $\frac{\pi R'}{100 \times 180.}$ K and the deflection are the factors of d′. Since K depends only on the range, it may readily be incorporated in the cotangent table. Compute "K cot a" for every five degrees in azimuth and every 100 yards of subcaliber range, or for every 1000 yards of service range. The lower part of the board consists of four lateral grooves, the first and fourth for celluloid indices as shown. The second groove is for an adding slide-rule, which places the deflection observed at B″ opposite that observed at BC, the scale for the latter being on the standing part of the board between grooves one and two. The third groove is for a logarithmic slide-rule, which has arrows at the ends. The numbers on the slide are in opposite direction from those on the standing scale below it.

7. The operation of the board is as follows:

(a) The spotter takes station in BC, and listens to the travel reader, keeping the T-square set to the nearest azimuth. He listens to the range called by the plotter, (or watches it on a drum, the shaft of which extends to the BC station from the plotting room), keeping the lower index on the standing scale, to correspond to the value of K cot a, for the latest range. This part of the spotters work is performed continuously or as the opportunity offers between his operations on the adding slide-rule. In case he is hurried he ceases to operate this part of the board, using the last placed position of the lower index in subsequent operation until he can get a chance to set a new range and azimuth.

(b) As soon as the deflections of the splash are received from BC and B″ observers, he sets the deflections opposite one another and sets the "over" or "short" reference number which is opposite the arrow index of the upper slide-rule, opposite his lower index, reading the actual "over" or "short" from the multiplying table opposite the arrow.

(c) The whole operation requires less than ten seconds from the splash to the spotters report, and is extremely accurate, and easy of operation.

(d) The construction of the left-handed board is similar to the one described, the adding slide being graduated in the same direction as the standing scale, but both of them being reversed without reversing the "over" and "short" reference scale immediately below them. This is considered to be a better plan than that of using the same board for all base lines and for both subcaliber and service practice; which, of course, can be done by including a subcaliber table at the bottom or top of the service chart and reading "overs" on the right of the reference scale when the base line is right-handed, and reading "shorts" on the right of the scale when the base line is left-handed.

PROFESSIONAL NOTES

British Naval Design—An American Tribute

Concurrently with the official statement from Washington that no expenditure for capital ship construction under the new three-year programme is to be incurred until after the conclusion of peace, an interesting report reaches us with regard to the six American battle-cruisers which were authorized in 1916, but apparently have not yet been laid down. When the original plans for these vessels were promulgated, their daring novelty evoked much criticism, mostly adverse, and from the very first it was doubtful whether they would be built on the lines proposed. It now appears that the laying down of all six ships has been postponed on the urgent recommendation of Admiral Sims, Commander-in-Chief of the United States naval forces in Europe, "until the efficiency of the new cruisers constructed by Great Britain has been investigated."

In the recently expressed opinion of Admiral Sims, the latest British vessels are "superior to the un-armoured but swifter vessels contemplated by America." As this officer has been in a position to study at first hand the trend of naval design in Europe for the last two years, his judgment naturally carries great weight, and we may take it that his virtual condemnation of the projected battle-cruisers—Constitution, Constellation, Lexington, Ranger, Saratoga, and one un-named—will result in the abandonment of these ships, so far at least as the initial plans are concerned. From time to time we have published such data of the "Constitution" class as were available, together with the technical criticisms to which the vessels were subjected and the rejoinder made by Admiral Taylor, of the Bureau of Construction. The main elements of the design were as follows: Length on water-line 850 ft., over all 874 ft., beam 90 ft., mean draught 30 ft. 11 in., normal displacement 34,800 tons. The machinery was to consist of turbines with electric reduction gear, designed for 180,000 horse-power and a speed of 35 knots. According to the Bureau of Construction's plan, half the total number of boilers were to be disposed above the water-line, where they would be protected by a curving steel deck. This arrangement was almost universally condemned, particularly by naval officers, who pointed out that the exposure of the generators to disablement by projectiles of medium caliber ran counter to the first principles of warship protection. The hull itself was to have an incomplete water-line belt of armor of no great thickness, but the main artillery positions and fighting stations were to be adequately protected. Ten 14-inch 50-caliber guns—in two triple and two twin barbettes, all on the center line—were to represent the main armament, with eighteen 5-inch quick-firing guns as an anti-torpedo battery. Of the eight torpedo tubes fitted, four were to be on the main deck, i.e., above water. Another distinctive feature was to be a special equipment for carrying and launching seaplanes. The estimated cost of each vessel when completed for sea was £5,500,000. Contracts for the first three had been placed with the Newport News Company—two ships—and the Fore River Company only a few weeks before the declaration of war on Germany, but in consequence of the heavy demand for destroyers and patrol craft which followed that event, all work on capital ships was temporarily suspended, and it does not appear that the three vessels were ever actually begun. That they would have been formidable ships goes without saying, but whether they would have had fighting qualities sufficient to justify the enormous cost is another question. One of the outstanding lessons derived from Jutland and other naval engagements of the war is the imperative need for robust protection in all vessels which are likely to come under the fire of heavy guns. Stout protection, in fact, was shown to be as indispensable a feature of the battle-cruiser as gun-power and speed, and it is precisely on this point that the plans of the "Constitution" class leave so much to be desired. The new British cruisers to which Admiral Sims refers are apparently the Hood and Rodney, the first named of which is expected to make her trials in the coming April. Few authentic details of this class are known, but the displacement is believed to be about 31,000 tons, and a speed of considerably more than 30 knots is anticipated. The main battery will be eight 15-inch guns. Unlike Renown and Repulse, the Hood is well armoured with a deep belt equal in thickness to that of any pre-war capital ship. Although somewhat smaller and certainly much cheaper than the Constitution, the Hood promises to be a better all-round fighting ship, and we are not surprised that Admiral Sims has come to the same conslusion.

Unofficial messages indicate that the "Constitution" class will be entirely re-designed, with all propelling machinery and boilers placed well below the water-line, a complete belt of armor, and a main battery of eight 16-inch guns. In other words, the essential features of the latest British battle-cruisers are to be incorporated in the new American ships. It need hardly be said that this decision implies a handsome compliment to British naval architects and shipbuilders, whose prestige has never stood higher than it does today. Just as the "Majestics" of 1893 became the universally accepted model for battleship construction in every foreign country, so our present-day capital ships, cruisers, and even torpedo craft are being duplicated more or less faithfully by all the leading naval Powers. It is, perhaps, the finest tribute of all that the United States, which has hitherto endeavored to plan its fighting ships on original lines, should now be on the point of rejecting a purely American design in favor of one embodying what we are entitled to regard as typically British characteristics.—*The Engineer.*

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The German Method of Registration of Heavy Batteries by Photography, Without Aerial Observation

(*Translation*)

The present development of aerial photographic reconnaissance permits the registration of heavy batteries without continuous observation by airplane, balloon, or ranging section, merely by previously locating the points of impact by means of airplane photographs.

This method is applicable in the first place to objectives located far within the enemy's lines, and against which fire for effect is not executed until later. The determination of location of the points of impact on the photographs gives the error in deflection and range in reference to all the objectives located near the point on which fire has been registered. In this way, registration can be effected, not upon the objective itself, but upon some point near it. It is well to vary the method of fire in respect to time so as to give the enemy the impression of a harrassing fire.

Attention is also directed to the following points:

1. Choice of the registration point:

(a) The terrain must be free from trees. The distance to the nearest woods must be such that long or short shots will not be hidden. The existence of near-by landmarks facilitates the work of the photographing airplane.

(b) The registration point selected must not have been the target for any fire since the last airplane photograph was taken. Any fire executed before the last photograph was taken has no importance. It is absolutely forbidden to fire in the immediate vicinity of the target before the first photograph taken after the ranging; this is especially important, as an airplane may easily photograph several rangings during one flight.

2. An effort must be made to eliminate as far as possible the dispersion due to variation in ammunition; therefore, ammunition of the same manufacture and properly stored should be used.

3. The points of impact must be clearly visible. If possible use nonsensitive, delay-action percussion fuses.

4. Determine the deflection and elevation from the firing board, eliminating atmospheric influences. Correct for angle of site.

5. Number of rounds, not over 10. (All rounds fired with the same angle of elevation and the same deflection and by the same gun.)

6. Record the shots. Request the divisional flight to have the registration point photographed the following day or the next favorable day, indicating exactly the square on the plan directour where the shots should be found. At the same time, inform the Army Corps as to the square of the plan directour, the number of rounds fired, the kind of projectile, and firing position. Measurements on the photographs are made by the Army Corps.

7. Later, when fire for effect is executed, take into account the corrections for meteorological differences between the present day and the one on which the ranging took place.

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The Aberdeen Chronograph

The Coast Artillery School has secured an Aberdeen Chronograph for the measurement of muzzle velocities. This will be used for instruction and experimental purposes.

The principle of the operation of the chronograph consists in measuring the time interval between the passage of the projectile between screens placed at measured intervals along the trajectory. Each screen consists of two conductors separated and insulated from each other. When the projectile hits the screen its point penetrates the conductors and the intervening insulator, "making" a circuit. This circuit is the primary of an induction coil, and in the secondary is a spark gap through which is traveling a strip of record paper at a very uniform velocity. When the circuit is "made" in the primary, the induced voltage of the secondary jumps the gap, incidentally piercing the record strip and leaving a record. When the next screen is pierced a similar record is made on the record strip. Knowing the speed of the record strip, the separation of the spark perforations allows the elapsed time to be computed, and this time interval is applied to the distance between the screens to obtain the muzzle velocity.

In the Aberdeen Chronograph the uniform, known speed of the record strip is obtained by means of a constant speed electric motor, which is direct connected to a hollow disk, or plate, on the inner surface of which is placed the record strip. The motor is maintained at 25 revolutions per second by a very sensitive governor. The circumference of the inner face of the plate is 50 cm., giving a linear speed of 1250 cm. per sec. Spark points approach near the inner face of the plate, the record strip just passing between the points and the plate. This plate, through the motor bed, is connected to one side of the secondary of each of the three screen circuits, and one of the spark points is connected to each of the circuits.

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Launching an Airplane from an Airship

By no means new is the idea of launching an airplane from an airship. For many years past artists have shown large dirigibles carrying one or more airplanes, for military and peaceful purposes. But it is one thing to merely confine such ideas to paper and quite another to realize such an achievement.

Several weeks ago the experiment of launching an airplane from a dirigible was successfully carried out at the Rockaway Beach air station of the Navy, near New York City. One of the large Naval airships was brought to the field and landed followed by five airplanes from the Mineola air school. When preparations for the test had been completed, the airship rose to a height of 100 feet, held by its anchor ropes, while one of the airplanes was wheeled into position below the large gas bag. The airplane was fastened to the dirigible by means of a 100-foot cable, dropped from the car of the latter.

These preparations completed, ballast was dropped from the dirigible. The airship rapidly rose to 3000 feet, with the diminutive airplane swinging below it at the end of the 100-foot cable. At the proper moment the airplane pilot pulled the release cord and freed his machine, which, with the engine "dead," went into a steep nose dive.

The force of the air in the downward rush was counted upon to crank the propeller and engine. After dropping about 1000 feet, the engine started with a roar, and the pilot then rejoined the four other airplanes which had been circling about, and in their company started off for the Mineola field.—*Scientific American.*

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The War's Influence on Naval Design

It is too early as yet to predict what effect the experience gained during the war will have in modifying future naval designs in a broad way. Whether it will produce radical changes in our ideas of the relative values of the various types of fighting ship, it is too early to say positively; but the present indications are that a fighting fleet will consist, for many years to come, of battleships, battle-cruisers, well-armed scout cruisers, and destroyers.

Coming down to details, it is not our purpose to go elaborately into the matter just now, but rather to point our some of the lessons which apply more particularly to first-line fighting ships—that is, the dreadnought, battleships, and battle-cruisers.

The great increase in the length of capital ships due to the rapid development of the battle-cruiser, brings to the front the problem of stiffness and longitudinal strength. During the war the British had battle-cruisers in action and on patrol work, that were over 800 feet in length. The experience gained suggests that special attention must be paid to the matter of the girder strength, or the resistance to bending stresses of these great ships. The problem is rendered more difficult by the natural desire of the line officers who fight the ship, to have their vessel present as small a target as possible to the enemy, especially in respect to its height above the water-line. It was a matter of remark among the officers of our own fleet that when the surrendered German battleships and battle-cruisers came in sight, and particularly when they came abeam, they gave an impression of sitting very low in the water. The battle-cruisers "Renown" and "Repulse" give the same impression. This low freeboard and absence of lofty superstructures is all to the good in rendering it difficult for the enemy to score hits; but from a structural standpoint, it is all to the bad; for if we lengthen the ship without making a corresponding increase in her depth, we lose in girder depth and consequently lose enormously in girder strength—lose in fact as the square of the depth.

Probably there is no more difficult task set before the naval architect than that of designing such huge vessels as our new battle-cruisers, 875 feet in length over all and of 35 knots speed. Their draft is subject to rigid limitations, their freeboard must be kept reasonably low. Consequently, compared with a trans-Atlantic liner like the "Aquitania" or the "Leviathan," they are very shallow for their great length. Furthermore, unlike the commercial ship, their enormous loads, due to the guns of 15- or 16-inch caliber with their immensely heavy barbettes, turrets, and magazines, are concentrated at certain specified points along the ship. To this is added the enormous weight of engines and boilers sufficient to give them their 180,000 or more horse-power.

The effect of this heavy concentration of weight and of the stresses due to the recoil of heavy guns, was shown in the case of the 35-knot ships of the "Furious" class, built during the war by the British. These vessels, of great length and comparatively shoal draft, were unable to stand the recoil of the two 18-inch guns, one forward and one aft, which were tried experimentally in the first ship of the class. The racking effect on the hull structure was such, we understand, that they were removed and 15-inch guns were substituted.

Another lesson of the war is the supreme importance of protecting the vitals of the ship against big-gun, high-explosive shell fire. It took the actual test of battle to show how searching is the flash of a bursting high-explosive shell of large caliber. The flaming gases of the explosion, white hot and under enormous pressure, search out the interior of the ship for unexpected distances. This was observed and commented upon by survivors from the "Blucher" which was sunk in the battle of Dogger's Bank early in the war. In the case of three British battle-cruisers at Jutland, the flash of 11- and 12-inch shells that came through the roofs or walls of the turrets, as the case might be, found its way down to the powder in the handling rooms in the bottom of the ship and set off the whole magazine. This happened in spite of the fact that the hoists to the guns were provided with cut-offs in the form of steel doors. Future construction will take note of this.

Necessarily these battle-cruisers are lightly armored compared with battleships. The protective value of armor was shown by way of contrast in the case of a battleship of the "Queen Elizabeth" class, which came under the fire of half-a-dozen German battleships. Although the ship was struck over 30 times by big shells delivered at moderate ranges, she came through without vital injury.—*Scientific American.*

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Copper Fouling of the Bore

Copper fouling of the bore due to the depositing of copper from the rotating band in the grooves increases the resistance in the bore and should be carefully guarded against. The following method of decoppering has been developed and is now used in the French service.

The process consists of introducing into the chamber of the gun an alloy consisting of 60 per cent tin and 40 per cent lead by weight which breaks up at the moment of firing into two components, the tin uniting with the copper in the bore of the gun to form a fusible brass alloy. The lead does not unite with the copper but acts principally as a lubricant for the succeeding rounds and tends to granulate the brass alloy and facilitate its removal.

Exhaustive tests made by the French have given rather surprising results. Not only is the process very effective in removing the copper, but it prolongs the life of the gun and increases its range almost equal to that of a new gun.

The alloy is used in two ways; in *decoppering rounds*, to remove the existing copper fouling and in *non-coppering rounds*, to prevent the accumulation of such copper from further firing. The alloy is issued in the form of thin bands folded flat and made up into 20 gram packages.

It is intended that future powder charges will contain sufficient alloy to prevent further copper fouling but until such a time as these non-coppering rounds can be issued continuously it will be necessary for batteries to make use of the decoppering rounds at various intervals to keep the guns in good condition. The cartridges and cartridge bags containing the alloy can be distinguished by the mark A-n, A referring to the alloy and n to the number of grams of alloy contained in the charge. Unless the charges are marked as containing the decoppering alloy it will be incumbent on the battery personnel to introduce the alloy into each charge before firing. In the absence of the alloy, certain batteries in France adopted the expedient of thrusting into the powder chamber, with the charge, the strips of tin foil in which fuzes were wrapped for shipment.—*Notes on Ammunition, C.A. School.*

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Machine-Gun Cooling Problem

The Inventions Section of the General Staff is desirous of obtaining a solution of the problem of improving the methods of cooling machine-guns during continuous fire, and the prevention of the freezing of the cooling liquid during cold weather when the gun is not in use.

At present the ordinary water-cooling system is used. It is necessary to transport several boxes of water for each gun in the field, as the water in the cooling jacket quickly turns into steam during firing. The following points should be observed in the solution of this problem:

1. It should be easily obtainable.
2. It should be easily carried.
3. It must not be too expensive.
4. It must not injure the metal parts of the gun.
5. If possible, it should be capable of being used several times so as to avoid extra weight.
6. A minimum of waste during use should be obtained.

It must not be assumed from the above that a cooling system for machine guns must necessarily follow the lines of the present water-filled jacket. Any efficient method of cooling will receive serious consideration.

Correspondence in regard to this matter should be addressed to the Inventions Section, General Staff, Army War College.—*Mechanical Engineering.*

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Listing Ships for Range

In the annual report of the Bureau of Ordnance, Admiral Earle states that the turret machinery on the "Mississippi" has been tested and successfully fired, with the ship listed 7½ degrees, which, with the guns at their maximum elevation of 15 degrees, gave the calculated range. This increase of range by listing the ship has been practised successfully by allied ships in various engagements of the war, and particularly in the long-range bombardment of the German fortifications at Zeebrugge and Ostend. We understand that in our latest turret designs the mounts are arranged to give a maximum elevation of 30 degrees, which of course, in any but very exceptional circumstances, would obviate the necessity for listing the ship. It is gratifying to learn that the type, 16-inch, 50-caliber naval gun has, in test, "proved successful beyond expectation, and this gun promises to be an exceptionally splendid piece of ordnance." It will form the main armament of our future capital ships.—*Scientific American.*

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Later Particulars of "Hush" Ships

The latest statement of dimensions regarding the so-called "hush" ships built for the British navy during the war, indicate that their dimensions, speeds, etc., as published during the war were greatly exaggerated. Thus, *The Engineer* gives the following dimensions for the battle-cruisers "Renown" and "Repulse": Length, 794 feet, beam, 90 feet; draft, 30 feet; normal displacement, 26,500 tons: and for the celebrated trio "Furious," "Courageous," and "Glorious," the dimensions given by the same authority are:

Length, 786 feet; beam, 81 feet; normal draft, 25 feet; and displacement, 18,600 tons. After the "Furious" was changed to a seaplane carrier, airplanes had no difficulty in landing on her deck after returning from a flight. She is credited with 18 torpedo tubes and with 90,000 horse-power for a speed of 31 knots, which, we are told, was very greatly exceeded in actual service.—*Scientific American.*

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Sixteen Inch vs. Eighteen Inch Guns

The removal of the 18-inch guns from the British cruiser "Furious," because their discharge stressed the ship's structure too heavily, suggests that our 16-inch fifty-caliber gun is about the limit of weight and power for naval ordnance. Our gun weighs 128 tons and its shell 2100 pounds; the shell of the 18-inch gun must have weighed some 3000 pounds and the gun nearly 200 tons.—*Scientific American.*

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The Torpedoplane of Reality

Ever since Rear Admiral Bradley A. Fiske, U.S.N., patented the torpedoplane back in July, 1912, this form of naval weapon has received some attention on the part of naval men. But it has remained for the British and the Germans to give the idea an actual tryout, and this they did during the last years of the great war.

The torpedoplane is nothing more than an airplane or seaplane arranged to carry one or more torpedoes which it can launch at surface targets from a distance of several hundred yards, to ensure accuracy of aim. The British have constructed torpedoplanes in which a single torpedo is carried between the floats or wheels, depending on whether the craft is a seaplane or land machine. The Germans have constructed similar machines. In some instances the torpedoplanes have had single engines, while in others they have been of the more powerful twin-engine model.

British naval officers sank two ships during 1916, by means of torpedoplanes. The Germans retaliated by sinking the British steamship "Gena" by means of one of their torpedoplanes. However, the war ended before either side could try out the torpedoplane on an extensive scale, hence the efficiency of this naval weapon is still a matter for conjecture. It is understood that a single torpedo weighing about 2,000 pounds is generally carried. More torpedoes mean a larger machine, which in turn means a better mark for the enemy gunners. Hence the single-torpedo type seems the best for the purpose.—*Scientific American.*

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Lateral Deviation of Projectiles

K. H. Guldner, in the *Zeitschrift des Vereines deutscher Ingenieure* for August 11 and 18, 1917, describes some investigations which he carried out to determine the lateral deviation of projectiles caused by the spin imparted to them by the rifling of a trench-mortar. The trench-mortar provides a suitable means of carrying out such tests as the motion of the projectile may be followed by the eye. Rifling with a right-handed twist may cause constant lateral deviation both to the right and left. Right or left deviation is the result of right or left precession, and is visible to the naked eye. Left precession with rifling having a right-handed twist can occur only after the maximum height of the trajectory has been passed if the center of action of the air-resistance lies behind the center of gravity of the shell. The precession on the ascending part of the trajectory is always greater than in the descending part.

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American Anti-Aircraft Artillery

The results attained by the American anti-aircraft artillery far surpassed expectations. The best Allied average of which any data is available is believed to be one plane for 8000 shots, and the best available figures indicate that the number of planes brought down by a single Allied battery since the beginning of the war is 17. On the other hand, the American 23rd Anti-aircraft battery brought down 9 planes in less than 4 months. The American anti-aircraft machine-gun troops, and search-light troops also carried on their work with aggressiveness and with results never before equaled.

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Italians Developed New Observation Balloon

The chief of the Aerostatic Section of the Italian Army, Major Avoria and Signor Prassove, Director of the Italian Army Aircraft Works, produced, just prior to the signing of the armistice, a new type of observation balloon, which proved much more satisfactory than the Parseval-Sigsfeld or Tribolal Caquot balloon. The new type is essentially a spherical aerostatic fitted with what are equivalent to stabilizing fins and acting as a kite. It may be employed in winds of over 55 miles an hour, while the Parseval type could not be used safely in winds exceeding 12 miles an hour. The new type requires less gas and owing to its smaller dimensions, is easily transported and housed, and safer from hostile fire. A further advantage in the employment of mooring cables of smaller section follows from its smaller head resistance, while should the mooring cable snap, the balloon may be navigated as a free balloon.—*Aerial Age Weekly.*

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The 14-gun "Agincourt" Not Popular

The British battleship "Agincourt"—formerly the "Rio de Janerio" building for Brazil and taken over by the British when the war opened—is notable for the fact that she has no less than seven, two-gun turrets, mounting a total of fourteen 12-inch guns as her main battery. Her protection of nine inches of side armor is reinforced by three protective decks, 17 main bulkheads, and 365 water-tight compartments. The ship, according to *The Engineer*, is a type quite alien to British naval ideas, which run just now to fewer guns of heavier caliber, and in spite of her formidable armament, she is not a very popular ship.—*Scientific American.*

BOOK REVIEWS

The British Navy in Battle. By Arthur H. Pollen. New York. Doubleday, Page & Company. 5¾"x8¼". 358 pp. 16 il. Price, $2.50.

The writer, Sir Arthur H. Pollen, generally considered the leading British naval critic, has had access to the official reports of the British commanders and has written a book of sufficient merit to cause its adoption by the British Admiralty as a guide in the reconstruction and organization of the Navy, made necessary by the war.

The author discusses the Battle of Jutland at length, giving Admiral Scheer, the German naval commander, somewhat more credit, and Sir John Jellico, the British admiral, rather less credit than has heretofore been given these commanders by British writers. In fact, the final conclusion seems to be that, if Admiral Scheer did not win, he certainly accomplished the plan which the superiority of the British fleet forced upon him, for the Germans not only inflicted superior damage, but "widened the range" when desired, and ultimately escaped with practically all their crippled ships.

mately escaped with practically all their crippled ships.

The book sets forth a complete history of the British Navy in the late war, and in addition contains interesting and instructive chapters on the principles of naval strategy, tactics, and gunnery. All major naval actions of the war are discussed and analyzed in a masterly way. The book is exceptionally well illustrated with line cuts, and will prove of more than ordinary value to the public in general and to Coast Artillerymen in particular.

The Modern Rifle. (*Volume 1.*) By J. R. Bevis, Ph. D., and Jno. A. Donovan, M. D., Montana. Bevis & Donovan. 5" x 7". 193 pp Profusely illustrated. Price, $1.25.

"The Modern Rifle" is a valuable addition to the library of an Artillery as well as an Infantry Officer. In this small volume the authors have condensed a mass of technical information which is clearly and cleverly arranged.

From an artilleryman's standpoint, one is struck with the similarity of the Gunnery Problem for both our service rifle and our 12-inch seacoast gun. The book deals primarily with the study of exterior ballistics as applied to a high-powered small arms rifle. In view of the developing of indirect fire for machine guns during the present war, this text would seem to be a valuable reference book for the Infantry Machine Gun Officer. For the civilian sportsman, who has a mathematical frame of mind, the book would prove most interesting. It would give him a good practical idea of the limits of his rifle for either field or range shooting. It would also give him an idea of the technical requirements of our Army Officers and show him the Gunnery Problems they encounter in their daily work.

Recruit Manual. By Col. George C. Thorpe, U. S. M. C. Philadelphia. J. B. Lippincott Co. 4½"x6". 168 pp. Price, $1.00.

An excellent resumé of the contents of this Manual is contained in the first eight lines of page 5 of the preface. To quote:

"When the recruit joins the Colors he finds himself admidst surroundings entirely new and his interest, naturally, is at high-water mark. He is then a personified interrogation point. That is the psychological moment to seize upon his interest and to fix a spell upon him that will keep his interest 'going'. The Manual provides answers to things he will wish to know the first day; it will tell him how to do things military; and it will excite further interest."

The principal advantage of this Manual over the many others which have been written, is the breezy, attractive beginning, which immediately absorb the recruits' attention. The subject matter is differently treated from that of other manuals, in that this one describes the many phases of the soldier's life when adapted to the various forms of modern warfare as conducted by our forces in Europe.

Mess Management. By Lieut. Col. William C. Dunn, F. A. Philadelphia J. B. Lippincott Co. 4½"x6". 111 pp. Price, $1.00.

This book is an excellent guide for both officers and mess sergeants in the handling of an organization mess. It treats of a very important subject which has not heretofore been presented in such a manner as to be interesting or attractive to the average officer.

The title of the book is well chosen. It actually treats of the management of a mess without going into the details of the cook's duties, etc. It discusses in a logical way how to prepare menus so as to give variety; how to avoid waste in buying and serving food; and it shows how the diligent application of these methods will result in the proper feeding of the organization on the ration allowance. All these methods are illustrated by concrete examples of what was actually done by organizations serving under the immediate observation of the author.

Koehler's West Point Manual of Disciplinary Training.

Secretary Baker testifies to the amazing rapidity with which Colonel Koehler's method, formed by years of experience at West Point, developed young men of every part of the country into military officers of impressive physical and moral adequacy. Wherever the object of physical training in schools, colleges, and other institutions is disciplinary and educational and not purely physical, this manual is easily adaptable and will prove exceedingly valuable. Individuals will find its directions very clear and most practical.

Alsace-Lorraine Under German Rule. By Charles Downer Hazen. New York, Henry Holt & Company. 5¼" x 7¾". 246 pp. Price, $1.25.

Professor Hazen says: "The present age ought not to have to be told the elementary truth that nothing is stable which is unjust." But he has delightfully and convincingly retold for us the age-old injustice to Alsace-Lorraine.

To a public that quickly forgets, these elementary truths must be told again and again, and the readableness of Professor Hazen's book makes it a most valuable addition to the library of the average reader, as well as to that of the historian.

Topographic Stadia Surveying. C. E. Grunsky, Eng. D., Men. Am. Soc. C. E. New York: D. Van Nostrand Company. 4¼" x 7". 100 pp. 18 il. 1917. Cloth. Price, $2.00.

This is a very complete text on the use of the stadia in topographic surveying, giving definitions, theoretical considerations affecting the construction of telescopes, the stadia formula, stadia reduction diagrams, use of the slide-rule in stadia reduction, methods of stadia surveying, practical suggestions, designs of stadia rods, samples of field notes, description of the platting of stadia notes, and eight tables. In a pocket is a stadia reduction diagram designed by the author.

The special features are the method of surveying and the special type of diagram furnished for the reduction of stadia work. By means of the diagram the use of stadia reduction tables are avoided and the problem is solved graphically. An excellent rod design is given, together with complete instructions as to its construction.

The book is of convenient pocket size.

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1919

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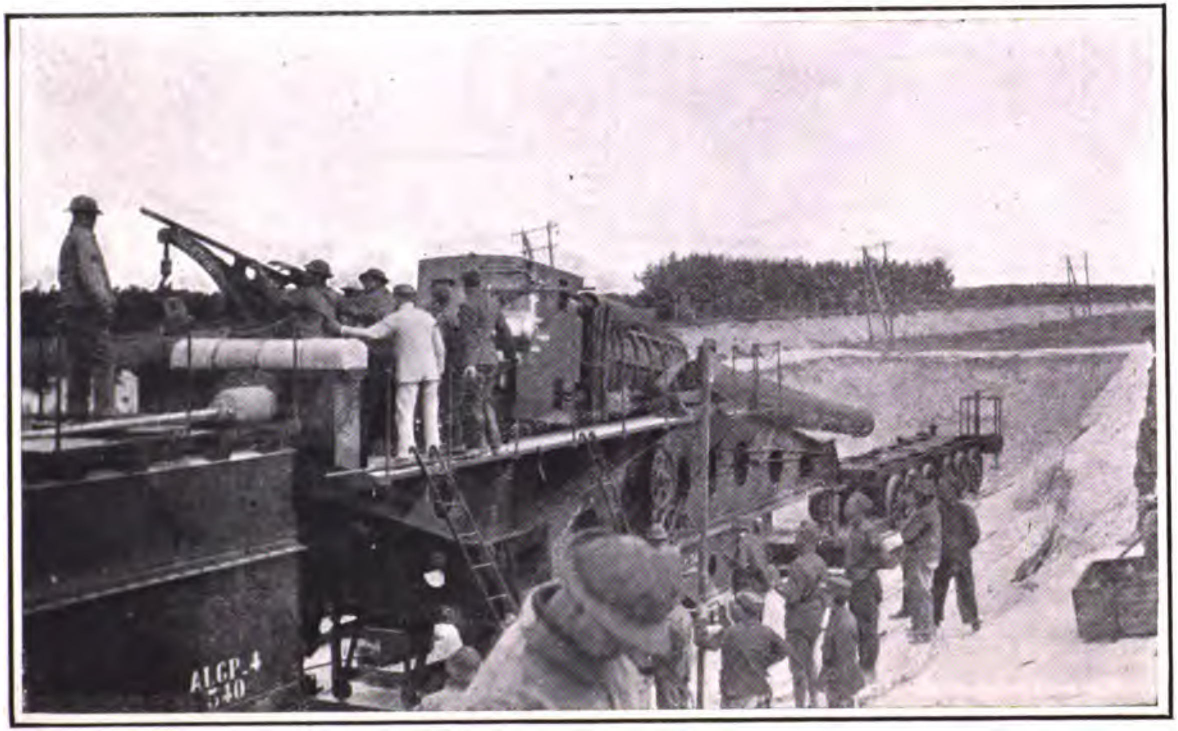

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First Prize, Essay Competition of 1918

Railway Artillery for Seacoast Defense

By Lieutenant Colonel Fred M. Green, Coast Artillery

> "Surely I hold that the best way is to keep our enemies from treading upon our ground: wherein if we fail, then must we seek to make him wish that he had stayed at his home. But . . . the encouragement of a first victory to an enemy, and the discouragement of being beaten, to the invaded, may draw after it a most perilous consequence." *Raleigh.*

INTRODUCTION

During the last few years there has been a gradually growing sentiment, not only within the army itself but also in the minds of many civilians, that the day of fixed seacoast defenses is passing and that future defense of our coast will be by means of heavy railroad guns and howitzers which can be massed at the threatened point when required. It must be remembered that certain fixed defenses will always continue to exist, either for covering narrow channels by fire from the most favorable sites, or for the protection of water-areas particularly adapted to mine defense, or for the protection of our most vital centers, whose defenses must never be withdrawn, no matter how severe the crisis at some other part of the coast. For such harbor channels as are bordered by islands, and whose approaches can be effectively commanded only from island batteries, the use of fixed defenses is also inevitable. However, there can be no doubt that in any project for the adequate fortification of our coasts, the additions should be made as far as possible in the form of mobile armament.

The purpose of this article is to inquire into the requirements of such armament, to forecast as nearly as may be the circumstances under which it will be employed, and to attempt a slightly more definite statement of its functions than has heretofore been presented. The discussion of the strategy and tactics of an arm of unknown potentialities is difficult, but not necessarily unprofitable, for it is only by a clear-cut conception of the ends to be attained and the requirements to be satisfied that a coherent equipment can be designed.

Since this discussion is limited to the employment of railway artillery for the defense of our coasts, fire upon immobile targets will not be considered. It is not intended to imply that such fire is unimportant in connection with coast defense; indeed, it is evident that when co-operating with a large body of troops in repelling an invasion, railway guns may render service of the utmost value by fire upon docks, roads, railroads, railway stations, freight-yards, storehouses or other elements captured by an enemy and important to his further advance. Again, should a hostile force land beyond the range of the guns of our fixed defenses and proceed to attack a city from the land side, thus avoiding its seaward defenses, the value of railway guns of large caliber in defeating his siege operations is manifest. In fire upon stationary targets, however, there will be used the methods which have been developed abroad during the last four years. No problem peculiar to coast defense is involved, and accordingly such applications do not lie within the scope of this article. The discussion will be confined to the exigencies of fire against moving naval targets, and will emphasize the value of the fire of heavy guns in preventing the main body of the enemy force from ever gaining foothold upon the beach. This is believed to be the proper function of coast defense railway armament while operating as such, and it presents many new and complicated problems.

So evident is it that a given gun confined to one position only is inferior in value to a gun of equal power, accuracy and range, but which is capable of being transferred from point to point as military needs may require, that there has been much loose discussion and looser thinking regarding the possibilities of coast defense by such means. So striking has been the use of heavy mobile artillery abroad, that it has been easy for the inflamed imagination to arrive at grave misconceptions regarding the use of such pieces in the protection to our seaward frontiers. Seacoast batteries will not trundle merrily along the shore, pausing from time to time to exchange shots with a hostile ship. The latter's time and ammunition will be too valuable to admit of participation in so admirable a test of the technical perfection of our system, and a willingness to engage in such an action would evidently be a confession of intent to decoy our railroad armament from the scene of the real attack. Equally fallacious is the expectation that bombardment of undefended coast cities by raiding vessels can be prevented by providing railroad guns. Such raids will be of short duration—an hour will probably suffice to attain the ends of destruction of property and the weakening of morale, which are generally the objects in view—and the transportation of railroad artillery to the scene and its preparation for fire within so short a time is hardly within the limits of possibility. The success of such raids can be prevented only by the construction of well equipped permanent batteries which will be capable of opening fire with but a few moment's notice.

Co-operation with Fixed Defenses

The fortification of a harbor implies its value to the nation, or its potential value to the enemy, and we may naturally expect that a fleet sent to capture it will be a powerful one. The existing defenses will find that they are opposing a concentration of force. Not only are they attempting to combat the naval armament of 1918 with their fire from the guns of 1888, but they are numerically outgunned by probably at least five or ten to one. Under such conditions, no matter what the form of warfare, the best remedy is to bring up the reserves and meet the hostile concentration of force by a similar concentration in the defense. One advantage of mobility in seacoast armament is thus made evident; it may prove invaluable for reinforcing fixed harbor defenses hard pressed by a superior force. Not only may guns be brought from adjacent sections of the shore-line, but further help may be provided from a general reserve consisting of guns brought across the country from the unthreatened or less-threatened coast. It is good strategy and good economics to make two guns fire where but one fired before.

The possibilities of this system are so attractive that it seems a pity to have to consider its limitations. The nature of the harbor itself may limit the value of railway armament: there must be avenues of approach for the railway lines, and there must be favorable positions for emplacing the pieces where their field of fire will embrace the channel. The number of our seacoast approaches which must be guarded mainly or entirely from islands, or whose neighboring peninsulas (if any) are now destitute of railroads, must be borne in mind. Also, it must be remembered that even though the shore defenses succeed in keeping off the attackers until we can match them gun for gun, our advantage is not yet as great as might appear. Not only are our guns of much less range and power than those carried by any modern fleet, but also a mobile gun of any considerable size will have a slow rate of fire both because of the shifting of its supports during firing and because of the difficulty of supplying its ammunition. Its total vulnerability including both personnel and matériel will be about that of a naval gun, and its foundation but little steadier. Tradition says that "a gun ashore is worth two afloat." This was doubtless true when the guns were contemporaneous and the former solidly emplaced, but so long as we oppose twentieth century fleets with nineteenth century guns, we shall be excusible if we prefer to try to reverse the ratio.

But the rôle of railway armament is not restricted to a mere concentration of gun power. It may prove invaluable for the correction of errors in the location of permanent works: e. g., to cover water areas not swept by existing batteries and from which the works may be taken in reverse, or to eliminate other dead angles—especially those sectors from which the city which was to be protected may be bombarded by indirect fire from the enemy's ships, using seaplane observation. It is needless to protest that blunders in the location of permanent works are inexcusable; any thoughtful artilleryman will admit that errors have been made, and that their consequences survive. Even though future appropriations may allow us to correct some of the errors of twenty years ago, a resourceful enemy might still demonstrate in the most unpleasant fashion the existence of further weak points in our armor. Such a situation, arising after the outbreak of war, can be met only by providing armament which is mobile.

It is further conceivable that a given port, the fortification of which was considered unnecessary in time of peace, may develop an unexpected importance in time of war, whether from the strategic maneuvers of field armies, or from some portion of an over-matched fleet having taken refuge therein, or from some other unforeseen cause. In such cases, an unfortified port might be immediately protected by the emplacement of railway guns along its harbor approaches. Such batteries, however, would have sacrificed their mobility, and may be subsequently regarded as immobile armament.

Operation in Unfortified Areas

We have previously shown that permanent forts are required to guard any seacoast city against sudden raids or bombardments made for the destruction of property or for the reduction of the national morale. If a city is of sufficient importance, it must be fortified; if it is not, the existence of mobile railway guns will not save it. In the case of unfortified sections of the coast, there exist four other principal classes of attack:

(1) Attack upon an unfortified city, for the purpose of occupying it as a base for the disembarkation and supply of a great army of invasion.

(2) Descent upon an unfortified port, or even upon an open beach, for the purpose of using it as a temporary base for the disembarkation and supply of a limited force of troops whose mission is to capture by land-attack some neighboring seacoast city which offers better facilities for an invading army, but whose permanent seaward defenses are of such strength as to render direct naval attack inadvisable.

(3) An effort to simulate either of the preceding operations, as a feint attack for the purpose of diverting attention from a genuine attack upon some distant part of the coast.

(4) Attack upon an unfortified city, for the purpose of extorting supplies, tribute, coal, or for any other purpose involving presence of the hostile ships for at least several hours.

Attacks of the first class are rather improbable; in general, ports too small to warrant fixed defenses are but poorly equipped with channels, anchorages, wharves, and railroad transportation to meet the demands of an invading army of great size. Attacks of the second class seem far more likely; the occupation of Gardiner's Bay for attack upon New York, or the seizure of cities like Salem or Gloucester for attack upon Boston, may be cited as reasonable instances. This has been a most common method for the capture of fortified cities, such as Alexandria, Louisburg, and Sebastopol. Attacks of the third order are nearly inevitable if any invading army is once dispatched. By simultaneous demonstrations at several widely-separated points, a considerable degree of confusion as to the actual landing point might be created; appeals for help from the city actually menaced may be partially or wholly neutralized by equally urgent demands from other cities at some remote portion of the coast. The fourth class of attacks seems the least probable; the contact mine, the seaplane, and the coast defense submarine make entering a hostile harbor, and remaining there for any considerable period, an unattractive prospect.

In reviewing these four types of attack, one is struck by the fact that so long as our navy is in a position to be of any material assistance, none of them is likely to occur. The first three classes are inconceivable until the enemy has attained at least a temporary mastery of the sea; the fourth and least probable class of attack will never be attempted if any considerable naval force of our own is operating in the vicinity. In discussing the function of mobile artillery in any of these cases, we must then presuppose that no assistance can be expected from the main body of our fleet.

Such being the case, it appears that too much reliance must not be placed upon the hope of early and definite intelligence of the enemy's movements. A convoy of troops will be covered by a screen of light craft, intent upon the prevention of its discovery by our scouts, both in order to avoid a concentration of submarines in its path and to avert a concentration of troops in the threatened area. The pleasant fiction of extended information from an improvised fleet of armed tugs and launches may as well be discarded—all patrol boats will be swept clear from the path of an army of invasion by their destroyer advance guard. Furthermore, the fleet's progress will be guarded by aircraft, not only to secure it against bombing and submarine attack but also to prevent detection of its movements by our aerial scouts. The notion of a seagoing screen of aircraft may appear extravagent, but in view of the present rate of aerial progress, and considering the time which must elapse before the completion of such a coast defense system as is now being discussed, it is evident that the realization of this feat of aerial navagation may fairly be considered. Accordingly, the consoling thought that we will in any case be apprised of the enemy's movements by aerial reconnaissance must be accepted with reservations. Screening a convoy from our aerial scouts will be far more difficult than the prevention of observation by naval craft, owing to their unlimited space for maneuver and their greatly increased range of observation; still, our scouts will be confronted by a tremendous aerial concentration, and it would be unwise to depend too much upon them. In short, it is when our navy and air-service have both been driven in that the coast artillery comes into its own.

Our inference from the foregoing discussion is as follows: when the need for mobile coast defense guns arises, we cannot look to either the navy or the air service for early and definite intelligence of the enemy, and the actual appearance of ships off our coast may very probably be the first positive indication of their intentions. Even then, the exact point of origin of the invasion will be concealed until the last possible moment. Reconnaissance of various harbors and possibly landings at several scattered points will be made, in order to mask the true point of attack and to harass the defenders and lower their morale by the well-known sequence of "order, counter-order, disorder."

From this, we see that emplacement of mobile guns before a threatened city, otherwise unfortified, *prior* to the arrival of any part of the invading army, is quite improbable. The landing of troops at an undefended port will consume but little time. The occupation of the city, the establishment of outposts, the disembarkation of a considerable additional mobile force, and perhaps the seizure or interruption of approaching lines of communication—all these are but reasonable manifestations of the activities of an aggressive enemy. How far this program may have progressed upon the arrival of our heavy railroad guns, it is impossible to say, but it seems reasonable to assume as typical that a considerable force of infantry troops will be ashore before fire can be opened by the heavy artillery of the defense. From this time on, the employment of coast defense armament ceases to be a deliberate laboratory exercise; we are confronted with a concrete tactical problem.

It is obvious that railway guns of large caliber are not an appropriate weapon wherewith to attack such forces as have disembarked; the eventual dislodgement of this advance guard will prove very simple if they can but be separated from their main body. The duty of the most immediate importance is the prevention of the further reinforcement of the troops already landed. The importance of this step can be realized only after considering the fact that the main body of the enemy will doubtless outnumber by many times the largest mobile force which we can assemble to oppose them at this period. Consequently, preventing them from joining the party which has already gained the beach is of enormously greater importance than is the fate of the advance-guard itself. It is in view of this principle that this particular function of the railway artillery is so strongly emphasized; this arm enjoys peculiar advantages which cannot be realized by any other, in that by timely arrival upon the scene, accompanied by but a small escort for its local security, it may attack the invader at the most difficult and critical point of his advance and so defeat the mission of a force a hundred times its own numerical strength. The success of this maneuver will depend largely upon the entry into action of the railway armament before there has been landed a force capable of overcoming its escort and silencing the pieces. The object of the artillery fire will be to:

(1) Destroy such transports as are within range, which presumably will eliminate the personnel on board them.

(2) By the threat of destruction, to keep the remaining transports as far as possible from the shore, thus compelling the transportation of troops in small boats for the greatest possible distance; this not only will retard the operation, but will expose the landing parties to the fire of available field guns, machine guns and small arms over the longest range and for the greatest period.

(3) To prevent naval ships from sweeping the beach and thus supporting the advance of landing parties by their fire.

It is believed conservative to state that the greatest single opportunity for the commander of a seacoast railway battery is a chance to prevent the disembarkation of an invading force at an unfortified port, or at a harbor whose fortifications have been reduced, by attack upon the transports. That a battery so employed will be attacked not only by the gunfire of all armed ships within range, but also by the use of all available troops already landed, is manifest.

This is not the only purpose which railway guns may serve. They may prove of great value in harassing transports or other naval ships in narrow waters such as Long Island

Sound, Delaware Bay, and the Chesapeake.* If the outer defense line be forced and the permanent works silenced, the passage of a fleet of transports may be delayed or even entirely prevented by directing upon them the fire of mobile guns at extreme range. Similarly, the reconnaissance of harbors may be discouraged through the use of railway guns, or they may be employed in denying the enemy the use of an anchorage.

Special Requirements for the Armament

Granting that we have as yet very little armament designed for this service, still a discussion of its problems appears timely; the design and construction of this matériel is the function of the Ordnance Department, but to enable them to supply us with a suitable equipment the requirements of the artilleryman must be clearly set forth.

The first and greatest special requirement for the armament for coast defense service is that the pieces should be capable of a rapid and fairly wide arc of traverse. The mounting of rigid carriages upon a curved epi, or the provision of a very few degrees of traverse only, are inadequate to allow the weapon to be effectively used against moving ships. Furthermore, a reasonably rapid delivery of fire must be assured, for any naval target is potentially a fleeting one. Finally, ease and rapidity of emplacement are most vital. It is evident that an added hour spent in the removal of the piece from its travelling position and the completion of its preparation for fire, may mean the disembarkation of a sufficiently great number of troops to defeat the entire mission of the battery.

Two general classes of carriages have been projected: they may be distinguished as (1) those involving permanent foundations, and (2) those capable of emplacement upon any firm and level ground or capable of fire from position on the track, using jacks and proper reinforcing when required. Armament of the first class offers the best firing platform and the greatest possibilities in the way of traversing. Parapets may be erected before these platforms in time of peace, and all necessary preparations may be made for the position-finding service: for instance, pedestals may be erected for depression position-finders, horizontal base lines may be laid out, searchlight positions may be deliberately selected, datum points triangulated, communication lines established, and the position in every way prepared for defense. For positions where the emplacement of railroad armament is most probable, and especially were armament of great size and power is required, the use of permanent foundations offers unquestionable advantages.

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* The importance of such service is in proportion to the attraction which estuaries, bays, and inlets offer for landing an army of invasion. Its transportation inland by water is rapid and convenient; the great initial penetration attained minimizes the time available for raising troops, has a depressing effect upon the national morale of the defender, and enables an attack to be launched at a vital point. The long and sheltered coast line available for landing facilitates putting the troops ashore and enables simultaneous landings to be made at different points. Finally, if strong defending forces are found on one side, the invader may at will cross over and land upon the opposite shore. The defender cannot guard both without undue dispersion, and can assemble upon either only with the greatest difficulty.

This system, however, involves certain very objectionable features. Artillery dependent upon previously-prepared and permanent foundations is not really "mobile artillery" but "artillery of alternative position." Its flexibility is greater than that of ordinary "artillery of position" only in proportion to the number of emplacements constructed. The use of mobile armament is principally in consequence of economic considerations; but for the question of expense, fixed defenses at every point would be preferable in almost every respect. Recalling the prices exacted for land suitable for seacoast batteries, and remembering the ordinary ratio of cost of emplacement to cost of gun and carriage, we find that the saving promised by making our pieces and carriages mobile is but slight if elaborate permanent foundations are required. Again, if the advantage to be gained from the ability to concentrate a large number of guns at a given point be considered, we see another great limitation of this system: an excessive number of emplacements must be built at *each* point whose occupation may be required. Furthermore, these emplacements must be guarded and kept in repair both in peace and in war. Again, the abandonment of a position located and brought under fire by the enemy, and the transfer of the battery to a new position, is impracticable owing to the limited choice of positions open to it. Finally, the advantages of surprise and secrecy are utterly lost; no matter how simple the emplacement, knowledge of its location cannot be concealed from hostile agents, and its position or approach-tracks may be attacked effectively, either before or during its occupation by the artillery, by naval gunfire, by landing parties provided with demolition equipment, and by bomb-dropping aircraft. Knowledge of where seacoast defense armament *must be* emplaced is only a degree less valuable to the enemy than knowledge of where it *is* emplaced.

For many reasons, it appears that the use of permanent emplacements is to be avoided whenever possible. We are then forced to consider the possibilities of armament which can be fired from any reasonable position. Among the principal limitations are (1) difficulty and slowness of emplacement; (2) difficulty of maintaining a stable foundation, especially under the shock of firing; and (3) the restricted arc of traverse usually encountered when temporary foundations are used. These difficulties may be expected whether the piece be fired from the rails, from a position over the rails (being raised by jacks), or from a platform assembled on or near the track. The degree of limitation, and the difficulty to be expected in overcoming these troubles, will increase rapidly with the caliber of the gun used.

The range and power of the armament suitable for use in railway seacoast defense is evidently limited by the difficulties of its emplacement. We must have the most powerful weapon possible, without sacrifice of mobility, stability during fire, and flexibility of traverse. At the present state of development of gun-carriage design it seems reasonable to believe that a 10-inch seacoast gun is probably the most powerful direct-fire weapon which can be fired from the tracks by the use of simple and rapidly-adjusted supports, and at the same time be provided with a traverse of about 60° (30° on either side of the center line of the track). This arc of traverse, while less than that of a permanently-mounted seacoast gun, will probably prove satisfactory: first, because any increase in this arc will greatly complicate the carriage design, increase its weight, and lessen the celerity of emplacement due to the precautions required against side-thrust; and second, because prudential considerations will demand a certain withdrawal from the shore-line to prevent the railroad pieces—doubtless outnumbered twenty to one by naval guns—from being smothered by their fire. This withdrawal from the waterfront (lessening the angle subtended by the field of fire), together with the possibility of emplacement at a different azimuth by selecting an alternative position on a track at some other azimuth, will probably enable the piece to cover the widest angles of fire required. In some cases, a judicious selection of a site will enable a piece of much more limited traverse to cover the entire channel, but dependence upon this principle alone should be discouraged.

It remains to be seen whether our present 10-inch pieces are capable of effectual emplacement on railroad carriages provided with this wide arc of traverse. There appears to be no valid reason to doubt the possibility of such an engineering achievement, and the large number of pieces of this caliber now existing, and which are obsolete for the attack of heavy modern naval vessels but of ample power for use against transports, serves to recommend the employment of guns of this size, even though a slight reduction in charge were required. There can be no doubt that the muzzle velocity should not be lowered below 2250 f.s.; it should rather be increased, for erosion will lose most of its terrors for us when relining is rendered as simple as it now is for naval guns by reason of the ease of transporting them to an arsenal. Any saving in shock should be effected by giving the piece a longer recoil and by the use of a lighter projectile, such as the Mark II, 510-lb. shell, of which there should now be a considerable supply on hand. Armor-piercing ability is not particularly required. Long range for mobile seacoast guns is more essential than for guns in stationary positions: the latter are protected by their parapets, and can be emplaced in close proximity to the channel, while mobile weapons may be constrained to fire upon a narrow passage at extreme ranges, for the sake of concealment and protection from naval gunfire, or because of superiority of strength of the landing party to the mobile army escort, or because the railroad at the point in question may run some miles from the shore line, or perhaps by reason of the interruption of railroad approaches by hostile demolition parties sent out by rail or automobile to a considerable distance from the harbor entrance. The piece should be so arranged as to admit of fire up to angles of 45°, and a "quick-loading" gear should be provided for depression between rounds.

Existing patterns of 6-inch guns appear to define the inferior limit for range and power of direct-fire guns. Such weapons are well adapted to attacking destroyers and light gunboats steaming close inshore, either in order to cover a landing by their fire upon mobile troops, or to assist the advance of a landing party along the beach by artillery support. Their light recoil, which not only admits of prompt emplacement but further tends toward stability and hence a rapid rate of fire, serves to recommend them.*

Howitzers and mortars present the great advantage of rapidity and simplicity of emplacement, owing to the more nearly vertical thrust of their recoil. They may fire from positions where they are perfectly protected from naval gunfire. Even at short range, the projectile from one 12-inch seacoast mortar has sufficient power to seriously damage the heaviest armored ship, and such pieces will prove an invaluable addition to the direct-fire armament above indicated when the attack of armored ships is required to prevent them from sweeping the shore with their rapid-fire armament, whether to cover the advance of further landing parties, to assist assaults by troops already landed, or in attempting the destruction of the railroad armament. For the attack of transports (which appears really the normal function of mobile batteries when removed from coast defenses) mortars are also very well adapted: their excessive time of flight, with consequently reduced accuracy when firing on a swiftly-moving target which pursues an irregular course, is of small disadvantage when firing on transports, owing to the limitations upon the movements of this class of target. To lower and man boats a transport must come to a halt, and it will then furnish an ideal target for vertical fire. Should the depth of water permit the transport to land troops directly at a dock, it must approach the latter by entrance through a channel. Since this harbor was assumed to be without permanent forts, it seems fair to infer that its channel is hardly of generous dimensions, and the movement of an ocean-going steamer through such narrow waters will not exhibit any great agility.

An armament for attacking naval targets may then be suitably confined to mortars of the general type of our present 12-inch seacoast pattern (or the 16-inch railway howitzer) and to direct-fire guns from 6 inches to 10 inches in caliber. Future increase in range and power of the direct-fire armament is desirable but not at the expense of ease of emplacement or width of the arc of traverse. It is possible that guns of greater power, mounted like the French 520 mm. howitzer upon a 32-wheeled car and equipped with electric motors for traversing upon an epi, might prove of value in some cases. It is doubtful, however, if sufficient handiness in traversing could be provided by such means, for the use of some cross-beams is probably inevitable. In any event, this type would require a good-sized and especially strongly-built epi, thus restricting such a weapon to the class previously described as "artillery of alternative position," with all the consequent disadvantages of this character of armament.

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* The trunnions have been removed from many 6-inch guns, Models 1903 and 1905, (formerly emplaced on disappearing carriages) in order to place them on wheel mounts, Model 1917. The remounting of these guns upon railway cars, rather than upon fixed pedestal mounts, is urged.

The vital need for rapidity of emplacement has already been repeatedly noted; in view of the speed with which troops can be landed if their disembarkation is unopposed, it is evident that every minute is vital if the escort is not to be overwhelmed by greatly superior numbers.* How rapidly pieces of the indicated types can be emplaced will of course depend mainly upon the perfection of the design of their carriages and this can profitably be estimated only by those experienced in such matters.

Position-Finding Service

It may be well to consider briefly the limitations in the choice of the seacoast position-finding service consequent upon this necessity for haste in opening fire. The long horizontal-base system will generally be practicable only for previously-prepared positions. Even then the probability of its use is materially decreased in view of the hypothesis that some enemy troops will have been landed prior to opening fire by the heavy armament, for the susceptibility of this system to interruption by small raiding parties is well known, and the extension of the defensive line required to protect its length will be evident. Circumstances, however, may demand its use, especially if fire against ships must be conducted at great ranges or by night. The measurement of the length of this base will have to be very rapidly effected by triangulation from a taped base,—say 300 yards long. Its azimuth may be arbitrarily assumed, the instruments being oriented on each other, and the panoramic sights oriented by the primary instrument. The secondary party may be sent out by side-car and a buzzer line laid for communication. The use of radio telephone sets for communication between the secondary station and plotting room has also been proved feasible.

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* The French Expedition to Algeria in 1830 landed 41,000 men in two days: the men were landed in small boats in a fortified bay, and the disembarkation was weakly contested. Other records show 18,000 men landed in five hours, and 6000 men in twenty-three minutes. At Aboukir Bay, the British landed 5500 men on the open beach in broad daylight in one hour in the face of a strongly posted and forewarned French force of 2000 men of all arms who were supported by flanking fire from a fort. At the Dardenelles, the British landed 34,750 men in one day, using seven separate beaches.

Depression position-finders are poorly adapted to the service of mobile armament, both because of the necessity of exact mounting upon a truly vertical pedestal of known height above mean low water, and because of the impossibility of adjusting them in the absence of datum points.

For general service, a wide use will probably have to be made of the short horizontal base or coincidence range-finder, of the pattern not dependent for adjustment upon datum points of known range, but capable of infinity adjustment by day. The unsatisfactory result obtained in using such instruments except in broad daylight and clear atmosphere is too well known to require comment.

The foregoing discussion applies only to those cases where railway armament is emplaced at a point away from the fixed defenses of a harbor, where no carefully measured base-lines exist. When it is utilized in connection with permanently emplaced batteries, upon a military reservation, the problem is greatly simplified. Under these conditions its position-finding system will in general resemble that of the immobile batteries, for all necessary preparations such as measuring base-lines, erecting pedestals and datum-points, and laying communication lines, can be made in times of peace. It may be noted, however, that in view of the potential concentration of a large number of guns at a single harbor, a grouping of guns into large units may prove advisable in the interests of simplicity. For instance, time, labor, and material may be saved and simplicity favored by providing but a single base-line for eight or ten 10-inch guns. Against modern naval ships, a less number upon a single target would probably prove so ineffective as not to justify the expenditure of ammunition, so that the efficiency of the pieces does not seem to be diminished by such an arrangement. In its favor, it may be noted that a single plotting board will serve to track the target (without prediction), and after each bell the range and azimuth of the target from some reference point may be sent to each sub-group (or to each single gun if necessary) for prediction (according to the range from that gun to the target) and for the application of the proper velocity correction (according to the variety of powder lots in use) and for the proper tide correction (according to the height of site of each particular gun or sub-group). The tracking conducted by each gun or sub-group would then be performed exactly as in the present vertical base system—the primary arm being set to the announced range and azimuth, prediction then made, and the range and azimuth of the set-forward point being determined from a gun arm. It will be observed that under this system the changing of base-lines is greatly simplified in the event of a base-end being neutralized by a smoke barrage, or rendered untenable by gas shell, or destroyed by hostile fire, or in case the target moves without the effective sector for a particular base; only one board need be substituted, no matter how many guns are in use. Uniformity of calibers or velocities is in no way involved, for the reason that the master board is concerned only with plotted points, leaving to each sub-group or gun the necessary prediction. Finally, the selection of the reference point is a matter of indifference, for its use is only for a graphic transfer in relocation, and the total destruction of this point will be without effect upon its use in position-finding.

Panoramic sights should be provided for all guns, for direct aiming will be exceptional. Considering the enormous discrepancy between the volume of fire of a fleet of naval ships with destroyers, and that of a couple of two-gun batteries, we see that to exist long enough to fulfil their function the batteries must take cover as completely as possible and fire by Case III. Normally, the directing piece and primary station may be made intervisible; if not, orientation must be accomplished through "carrying an azimuth" by a transit. The use of aiming stakes to avoid interference by camouflage seems probable, as they appear handier to use than an aiming-rule in the case of moving targets. The use of a panoramic sight appears preferable to any attempt to use an azimuth circle for indirect fire, owing to the possibility of the shifting of the platform from recoil. The sight should have two independent horizontal motions: a limb to be set during orientation from the nearer base-end, and a graduated circle for laying off the corrected azimuths. Simplicity in the fire-direction system would also be favored by the provision of a third scale of limited arc, for setting deflection when Case II fire was possible.

Elevation will naturally be by quadrant, using an arc graduated in ranges as is common for light artillery. Corrected ranges will be sent from the plotting car. Since the height of site will vary for each new position, it would seem advisable to graduate the range scale for an assumed height of trunnions—say, 40 feet for the Atlantic Coast—and to compensate for estimated or measured departures from this standard condition by an extension of the tide-curves on the range-correction board.

TRANSPORTATION

Plotting cars, radio cars, searchlight cars, and machine-shop cars, as outlined by Colonel Wildrick, (J.U.S.A., Vol. 47, p. 129) are essential. It is suggested that the plotting car contain the battery commander's office, and that a separate car be provided for the coincidence range-finder, for the plotting room should be placed under cover, but the range-finder must be in the open. It will be advantageous to so arrange the power-plant of the searchlight car that this can be capable of motion (say at 6 or 8 m.p.h.) without the service of a locomotive, not only for the reason given by Colonel Wildrick, but also because there is naturally going to be a great deal of track congestion where even a single battery is being emplaced.

The amount of railroad construction equipment and material to be carried cannot be predicted. It will vary widely with the condition of road-bed in the allotted sector, as well as with the type of carriage employed. In any event, the delivery of fire from the tracks of a main railroad will be very exceptional; to obstruct both tracks of a double-tracked coast railway would be to hamper the concentration of defensive troops to a prohibitive degree. To what extent existing sidings, spur tracks, or branch lines running from the main traffic route can be used for the delivery of fire, or as a means of conveying the pieces to a suitable location for a firing platform, is one of the many practical railroad problems for which no theoretical solution is of value. The evolution of the matériel of this system demands the co-operation of experienced railroad men and gun carriage designers; the artilleryman should confine himself to his proper rôle of stating the requirements to be met.

On one point, however, an opinion may be ventured: in addition to regular troops, the services of professional railway men must be instantly available upon the outbreak of war. No artillery officer can expect to master all phases of railway work in addition to his other military duties, nor can troops be so well instructed in train-operation, track-construction, and other similar work as to duplicate the rapid and resourceful performances of men habituated to this work through years of constant experience. The employment of artillerymen as amateur railroad men promises no greater efficiency than the use of railroad hands as amateur artillerymen. Moreover, a gun-crew cannot be expected to serve their piece with full efficiency immediately after hours of intense labor in laying track. The solution of this problem of personnel must depend upon pending legislation. If compulsory military training be established, railroad engineers, firemen, conductors, wreck-masters, section-hands, etc., should be assigned to work of this nature. If not, an Enlisted Reserve Corps unit of such men should be organized, especially from the personnel of non-strategic lines. In any event Reserve Corps commissions should be issued to such railway officials as will be in charge of the operation of the coastal railways in time of war, and to others selected for duty upon the staffs of artillery commanders.

Tactics of Local Defense

One of the most common axioms of textbooks is that artillery cannot operate independently—that without the support of infantry, it is helpless. This truth is fully appreciated by the field artillery, but coast artillerymen have been forced to the presumption that divine aid must be invoked to cover their rear. Concentration upon technical refinement has overshadowed a just appreciation of the eternal tactical principles. For railroad artillery any neglect of local security will be more obviously fatal than in the case of fixed batteries, for the mission of the mobile guns requires them to approach a spot where a considerable body of hostile troops may be assumed to have already landed. High water mark will not prove a barrier to the operations of an invading force, and hence the study of the *type* of escort to be provided is forced upon us; its *size* will naturally be determined by military exigencies, according to the principle attributed to General Forrest: "Git there fustest with the mostest men."

The landing of any considerable amount of field artillery at the start of disembarkation is improbable, and though a few landing guns may be put ashore, the bulk of the opposing troops will naturally be armed as infantry. For the local defense of the pieces and their auxiliaries, the proportional use of field-guns and machine-guns should be high. The former will be most serviceable in keeping the hostile forces beyond effective small-arm range; the latter give the greatest volume of fire for a given number of troops to be transported, and are also effective at extreme infantry ranges. To allow the approach of invading troops to a point where effective small-arms fire can be maintained upon the heavy armament spells total failure. Accordingly, the service of security and information must have all possible mobility, and a wide use of motorcycles and motorcycle machine-guns is proposed, since these furnish the maximum return per unit of car space required for their transportation.

It may further be suggested that the escort has not only to protect the vicinity of the battery, but may also have to contain such forces as have been landed and to deal with such small boats as persevere in attempts to reach the shore. It is not intended to imply that coast artillery troops will predominate numerically in a properly balanced organization for this service, but it appears evident that the combination of heavy guns with a mobile escort can attain ends which could not be realized by a force many times as great but not equipped with long range artillery. The history of landings shows that the success or failure of attempts to disembark under fire has often been determined by the closeness with which the transports could approach the land. (The beaching of the "River Clyde" at the Dardanelles illustrates an extreme measure taken to avoid the exposure of a landing force to hostile fire while in open boats.) With the increase range and accuracy of small-arms, and in view of the especially deadly fire of machine-guns when firing over water where spotting is easy, this is more than ever true. Meantime, the ranges of heavy artillery have increased to the point where transfer of troops into small boats may be required at enormous distances from shore, thus giving the defender every opportunity for the effective use of fire in protecting the beach.

The three-dimension character of modern warfare must not be disregarded. Anti-aircraft armament, mounted on flat-cars, must be a component part of each battery, together with the *additional* personnel required for their service. The time has come to abandon the cheering conception that naval attacks, infantry attacks, and airplane attacks are separate phenomena which will occur successively at distinct periods, just as infantry and artillery training are allotted to different seasons of the year. The most obtuse enemy will appreciate that these attacks must be synchronized, and will proceed accordingly.

CONCLUSIONS

1. Railroad armament can never entirely replace fixed batteries.

2. In the defense of an already fortified harbor, railway guns may furnish an invaluable reinforcement to the immobile armament.

3. In certain cases, railway guns may be immobilized for the temporary protection of a harbor not regularly fortified, but whose strategic importance has been increased by unforeseen causes.

4. Due to their mobility, they furnish a shifting defense for the shores of narrow waters, and may harass an enemy attempting to operate therein.

5. The most vital function of railway artillery appears to be the attack of transports in the prevention of invasion. Troops in transports can be destroyed with a facility which cannot be approached under any other conditions.

6. In the performance of the latter duty, the guns must be accompanied by an adequate escort of mobile troops, both for the protection of the pieces from such forces as may have landed prior to their arrival, and for the attack of personnel landing in small boats. Independent operation is inconceivable, but no more so than is the operation of a mobile force unaccompanied by artillery of great power and long range.

7. Since their most important targets are unarmored, existing guns from six to ten inches in caliber may profitably be utilized. Future increases in range and power are desirable, but not at the expense of the handiness of the mount. The provision of howitzers and mortars is strongly to be recommended.

8. It will often be advisable to resist firing upon tempting naval targets until the transports are within range. The commander of railroad guns must not allow himself to be enticed into an artillery duel with the naval escort. The latter may always disengage by steaming out to sea after effecting such a diversion to prevent interference with an important landing elsewhere.

9. Since timely entrance of the first battery into action is of paramount importance, a certain strategical dispersion

of railway armament is admissible, if by this means the opening of fire by a single battery may be materially expedited. Rapidity in transportation of the pieces to the scene of the landing, and smartness in their emplacement and preparation for fire, cannot too often be mentioned.

10. In entrance into action, a battery must unhesitatingly be pushed forward to a point where it can execute its mission; the ends to be gained are so great as to amply justify the risk of losing a few guns. Furthermore, a battery once in action must be sacrificed without hesitation if by so doing the landing of troops can be delayed to the uttermost. But since railroad batteries will normally find themselves opposed by an enormously superior volume of fire from the ships, they must as far as possible adopt the tactics of the franc-tireur, firing from cover and avoiding a downright engagement with overwhelming forces.

11. The railroad approaches to the point of attack are as vital to the defense as is the line of communication to an invading army, and must be organized and protected with equal care. Their security is a problem in which all arms of the service are deeply concerned, but since this matter is so intimately involved in any railway artillery project, we must devote especial thought to its solution. It is not the least of the problems which confront us.

Coast Defenses Constructed by the Germans on the Belgian Coast

Submitted by Major A. Norton, C.A.C.
and Major D. Armstrong, C.A.C.

INTRODUCTION AND PART I

Introduction

The study of the German fortifications on the Belgian coast was undertaken for the purpose of obtaining technical information concerning a system of coast defense that had for over four years withstood many attacks of strong Allied naval forces. The purpose of this report is to describe and enumerate matters of interest to the Coast Artilleryman, but without any attempt to enter deeply into the subjects of historical development and tactical organization.

The German coast-batteries in Belgium were originally planned with a view to providing with the least delay an effective local harbor defense, and to this end the first elements were installed in the vicinity of Ostende and Zeebrugge, both of which were important submarine bases. These defenses were gradually enlarged until they became sufficiently formidable, by virtue of their power and extensiveness, to be classed in the category of a complete coast defense inasmuch as they actually protected the entire Belgian coast from Nieuport to the southern border of Holland. This is evidenced by the fact that the repeated naval attacks were successfully repulsed from 1915, the date which marks the completion of the first important German battery, until the time when the Germans evacuated the Belgian coast in October 1918, as a result of pressure from the land side rather than from the sea.

It is deemed advisable to bring special attention to certain conditions which existed along the entire coast at the time the data for this report was collected; this, in order to explain why certain matters are not described in greater detail and why the necessity for expressing an opinion rather than stating a fact occasionally arises.

In the first place, all batteries abandoned by the Germans were almost completely wrecked by them before departure. There was only one gun and emplacement which were nearly intact. Secondly, all gun equipment, fire control matériel and such other articles as would serve to indicate the details of operation were removed or destroyed.

Under such conditions it was impossible to determine with accuracy all the details of tactical organization and the system of fire control and direction.

It has therefore been necessary to base conclusions upon what evidence remained and every effort has been made to make logical deductions therefrom. Unfortunately, some details are necessarily lacking, but the major portion of the following report represents the actual facts and the remainder, what can safely be classed as reliable and the best obtainable information.

PART I

Grouping and Composition

The installation of batteries by the Germans on the coast of Belgium began shortly after that country was invaded and continued up to the time the Germans were compelled to evacuate in October 1918.

The numerous coast batteries cover a front which extends from Middelkerke to a point within a short distance of the Holland border, a front of about 25 miles. The dispositions are such that the batteries naturally arrange themselves into two distinct groupings, one centered about Ostende on the south and the other about Zeebrugge on the north.

Ostende Grouping

The Ostende grouping was contained in the front Middelkerke to Wenduyne and consisted of the following principal batteries. The exact location is shown in Appendix I.

* Deutchland	4—38 cm. guns	(Named Battery Jacobinessen by the Allies).
Hindenburg	4—28 cm. guns	
* Hannover	4—28 cm. guns	(Doubtful as to which group this Battery belonged.)

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*Batteries Deutchland and Hannover can effectively reinforce the Zeebrugge grouping.

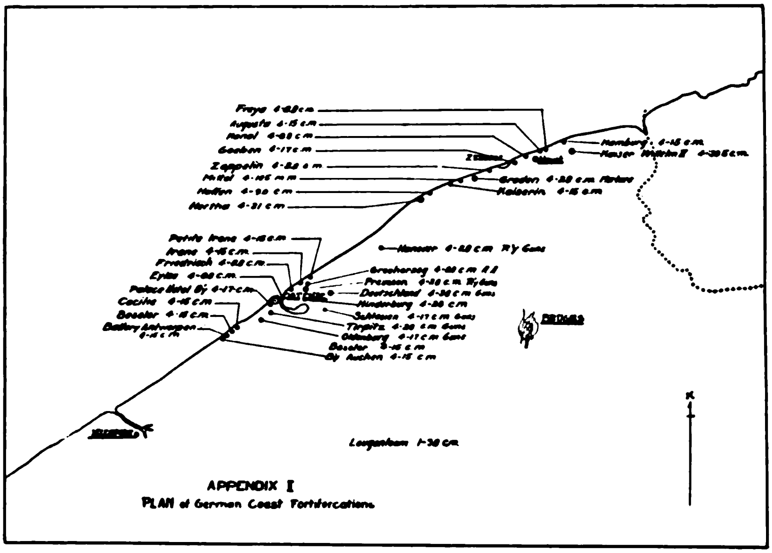
Tirpitz............4—28 cm. guns

Preussen..........4—28 cm. guns (Named Battery Turkijen by the Allies).

Oldenburg........4—17 cm. guns

Schlesien..........4—17 cm. guns

Antwerpen.......................(The guns of this battery were removed and probably mounted near the Palace Hotel; for want of something better the new and un-named battery will be referred to as the Palace Hotel Battery).



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Palace Hotel.....4—17 cm. Guns.

Petite Irene....4—15 cm. guns

Irene..........4—15 cm. guns

Aachen........4—15 cm. guns

Beseler.........4—15 cm. guns

Cecilie.........4—15 cm. guns

Hylan.........4—8.8 cm. guns

Friedrich.......4—8.8 cm. guns

Grossherzog...4—8.8 cm. A.A. guns.

In addition there were many small un-named batteries for anti-aircraft and land defense.

The above list of batteries represents an armament of

4—38 cm. guns
16—28 cm. guns
12—17 cm. guns
20—15 cm. guns
12—8.8 cm. guns.

Some of the principal batteries listed above will be described in Part II.

Zeebrugge Grouping

The Zeebrugge grouping was contained in the front Wenduyne to the Holland border and consisted of the following principal batteries. Their exact location is shown in Appendix I.

Name		
Kaiser Wilhelm II		4—305 mm. guns
Hertha		4— 21 cm. guns
Groden		4— 28 cm. mortars
Goeben		4— 17 cm. guns
Kaiserin		4— 15 cm. guns
Augusta		4— 15 cm. guns
Hamburg		4— 15 cm. guns
Mittel		4—105 mm. guns
Bremen		4— 90 mm. guns
Hafen		4— 90 mm. guns
Kanal		4—8.8 cm. guns
Freya		4—8.8 cm. guns
Bootskenonen		4—8.8 cm. A.A. guns
Zeppelin		4—8.8 cm. A.A. guns
Brunhilde	A.A.	Caliber unknown
Hessen	A.A.	Caliber unknown
Sachsen	A.A.	Caliber unknown.

In addition there were many un-named batteries for anti-aircraft and land defense, and Battery Het Zoute under construction, February 1918, thought to be a 28-cm. R.R. gun battery, not verified.

The above list of batteries represents an armament of:

4—305 mm. guns
4— 28 cm. mortars
4— 21 cm. guns
4— 17 cm. guns
12— 15 cm. guns
4—105 mm. guns
8— 90 mm. guns
16—8.8 cm. guns.

Some of the principal batteries listed above will be described in Part II.

TACTICAL ORGANIZATION

The tactical organization of the fortifications of the Belgian coast must necessarily be deduced from the names of stations located on a captured German map, inasmuch as nothing remained on the ground to indicate the chain of command. It is apparent, however, that the control of the entire coast defense system rested in a single individual, i.e., the Artillery Commander of the North Sea, whose P.C. was located in Ostende near the Mole. From this point radiated the lines of communication to the subordinate commanders of the grouping, divisions as follows:

The Ostende grouping was divided into two commands, a North and a South group, each under a Battle Commander. Battle Commander at P. C. Weichel controlled the elements south of Ostende and the Battle Commander at P. C. Oder controlled the elements to the north. The boundary between the commands is marked by the City of Ostende and the Bruges Canal.

The Zeebrugge grouping was, as far as available information indicates, under a single Battle Commander, P.C. Weser, but the disposition of the armament and the natural boundaries in this grouping led to the belief that there were two Battle Commanders, one as just mentioned, but commanding only the defenses centered about Blankenberghe and south of Zeebrugge, and the other commanding the defenses centered about Heyst and North of Zeebrugge.

There was nothing to indicate that there was any intermediate command between the battle and Battery Commander, such as would correspond to the Fire Commander in the U. S. Coast Artillery.

LOCATION AND DISPOSITIONS

Topography

In order better to understand what follows, a few brief remarks concerning the topography of the Belgian coast are necessary. A line of sand dunes runs parallel to and within a few hundred meters of the shore and is only interrupted by the city of Ostende, the towns of Heyst, Blankenberghe, Wenduyne, Middelkerke, and Westende, and also at Zeebrugge where large canals connect with the sea. The average distance of the center of the first line of dunes from high water mark is about 100 meters. The average height of the dunes above M.L.W. is about 12 meters. The depth of the line of dunes varies from 75 meters to 1000 meters. A splendid highway follows the shore line. South of Ostende it runs generally in front of the dunes, whereas to the north it runs in rear except where it passes through the towns. Back of the dunes the country is very flat, and sparely settled between towns. Very few trees and nothing that could be called a wood is to be found within five kilometers of the shore. The average elevation is about 3 meters above M.L.W.

For a distance of about two kilometers inland the soil is generally very sandy, and after that it becomes very rich and the vegitation is more continuous and dense.

Primary Armament

The most striking and interesting feature of the location of the primary armament was its general withdrawal from the immediate coast line to widely scattered positions, at distances varying from one-half to two kilometers from the shore. This was the case with Batteries Deutchland (4—38 cm. guns), Kaiser Wilhelm II (4—305 mm. guns); Hannover, Tirpitz, Preussen, and Hindenburg (each 4—28 cm. guns). Only two exceptions are to be noted, i.e., Battery Groden (4—28 cm. mortars) located just in rear of the dunes, and Battery Hertha (4—21 cm. guns) located on top of the dunes. This latter battery, it is interesting to note, is the only battery of the primary armament that could actually see its targets, as all other primary armament was so disposed that a view of the water areas is impossible. Practically every gun of the major caliber had all round fire.

Intermediate Armament

The only batteries of the intermediate armament that were not located in the line of dunes were Oldenburg and

Schlesien. These two batteries were well back from the shore line located on perfectly flat terrain. Neither of these batteries could use Case I and II.

Secondary Armament

All batteries of the secondary armament used exclusively for coast defense were located close to the shore and in the line of dunes.

Anti-Aircraft Artillery

Anti-aircraft guns, with few exceptions, were located well back of the shore line. The only A.A. gun battery that was found on the shore line was Battery Zeppelin (so named by the Allies). This battery was of necessity placed there in order to protect the Mole at Zeebrugge and also could be used for general harbor defense purposes. This Mole was the resting place for many sea-planes and many hangers were erected thereon.

Anti-aircraft machine guns were located close to the batteries to which they pertained. Practically every battery abovc 105 mm. had at least two machine gun positions. These positions were usually on the flanks and generally symetrically disposed.

Land Defense Artillery

Land defense artillery was for the small calibers located well forward and in front of the line of dunes. Many small field pieces and some of larger caliber were located in the vicinity of Middelkerke. These batteries served the double purpose of protecting the left flank of the coast defenses, as well as fortifying the infantry positions further south, which formed a part of the Western Front.

Aside from machine gun nests there were no land defense artillery positions in rear of the line of batteries.

Infantry Positions

Infantry positions commanding the approaches from the beach and from the rear and flanks were numerous. There is an almost continuous line of trenches along the entire coast. Additional works practically encircle each separate battery or group of batteries. Barbed wire is used extensively in front of all trenches.

Stations

All stations escept those used purely for lookout purposes, are located in the forward line of dunes. The observing level is below the line of fire of neighboring batteries. The distance between observing stations of the same battery varies from about 12,000 meters for Battery Deutchland to 400 meters for Battery Antwerpen. The P.C. for batteries located in the line of dunes is found on the flank and rather close to the battery to which it pertains. For batteries back from the shore line the P.C. is always found in the dunes. Where a battery has two observing stations the P.C. sometimes lies between them, sometimes not; but is always found close to one or the other. The batteries of the primary armament without exception, have two observing stations. Practically every tower or high structure along the coast was utilized as a station. It is impossible to say whether or not they were used as lookouts and spotting stations exclusively. The indications were that such was the case, as there was no evidence to show that they were tied in with any particular battery or station. These stations were undoubtedly for general use of the battle commands in maintaining a lookout and observing the effects of fire.

Quarters

Living quarters were located either in or near the batteries and stations that the personnel served. These quarters when separate, were placed in the rear slope of the dunes. For batteries located back of the shore line, quarters were provided either in the emplacement proper or in a structure nearby.

Searchlights

Searchlight stations were not numerous. Only three were found along the entire front from Ostende to Middelkerke and only two between Ostende and Heyst. The former covered a front of about 3600 meters and the latter two were 18,000 meters apart. Judging by the power plant installations, there were more lights in the Zeebrugge grouping than just mentioned. In the Ostende grouping there remained the wrecks of only three searchlights although four positions were found. It appears that the fourth position in the Palace Hotel was prepared only after the exploit of the Vindictive and, the light from the shelter located near Battle Commander's station Weichel was installed therein. The level of the lights was without exception below the line of sight and observation of nearby batteries and stations. All searchlight stations were located well to the front of the line of batteries and stations and in fact, as near high water mark as possible. The remains of one portable searchlight outfit was found; its assignment was not determined.

Power Plants

Separate power plants were not much in evidence. Existing municipal installations were undoubtedly utilized as much as possible; small plants located in the dunes furnished power to a group of batteries. A plant existed in the Palace Hotel. The larger and isolated batteries had a separate plant located near the battery.

TYPES OF GUNS, CARRIAGES, STRUCTURES AND INSTALLATIONS

Guns

Many models of guns were found; among those verified were models dated from 1887 to 1916. The length varied from 35 to 45 calibers, but the longer gun was only found in the smaller calibers using high velocities. All modern primary and intermediate armament was 40 calibers. Velocities used ranged from $V^0 = 455$ to $V^0 = 765$ m/s. The more modern guns used high velocities for all calibers. The average maximum range of the primary armament was 30,000 meters, of the intermediate 17,000 meters, and of the secondary armament 12,000 meters. Practically every gun seen was manufactured by Krupp. The sliding breech block was universal. As some of the projectiles at nearly every battery had two rotating bands it would appear that the standard twist of the rifling was uniform. It was impossible to determine whether or not any guns were of wire-wound construction. The exterior form of the chase of all guns resembles that of U. S. models. The separation between hoops and the protruding of the tube was noticed in many cases. Obturation was effected by means of a brass cartridge case for all calibers. The propelling charge was ignited by means of a percussion primer. Erosion and copper fouling were not much in evidence.

Carriages

Like the guns, there were many models of mounts; no two batteries of the same caliber were found to be alike. Some models were old, while others were very modern. All mounts, except a few herein-after mentioned, were of the barbette type, carrying a shield or a turret with armor ranging in thickness for the smallest caliber from 2 cm. to 12 cm. for the larger. However, the thickest armor was found at a turret battery of 17 cm. guns; the 38 and 28 cm. guns used only 6 cm. armor. Some of the intermediate and primary armament had undoubtedly been removed from warships. Several of the 15 cm. and 17 cm. batteries still carried a shield typical of that used in sponsons, but this shield was augmented with side and top plates so as to protect the gun crew. There was nothing unusual about the turret guns; there were only a few batteries with that construction. The following batteries of the primary armament had no armor protection whatsoever: Preussen, Hannover, and three guns of Deutchland. It is generally understood that the unprotected guns of the last-named battery were to have armor attached, as was the case with No. 1 gun of that battery. The other two batteries were of the railroad type and never contemplated the use of armor. All other batteries were protected. Guns of the primary armament were mounted on carriages of the front pintle type, this being true with the exception of a battery of 210's in turrets. The intermediate and secondary armament used the pedestal type of carriage. The designs of carriage permitted maximum elevations which ranged from 15° for oldest models to 55° for the more modern; depression angles of −5° were possible with the former, but the latter as a rule would not permit of any depression. Recoil and recuperator mechanisms were combination spring and hydro-pneumatic. This system usually consisted of three cylinders disposed in different manners, but operating always on the same general principle. At battery Tirpitz the system employed used two sets of three cylinders each. Further details are given in the description of the batteries in Part II. With few exceptions all-round fire was possible. Range scales were, without exception, mounted on a flat bracket attached to the cradle, sometimes on the left and sometimes on the right, depending upon which side the elevating hand-wheel was located. This bracket was cut on the arc of a circle and the face was usually parallel to the axis of the gun. The bracket had an undercut groove into which was inserted the brass range scale. This scale was graduated in meters and a separate column was used for the different types of projectiles. A degree scale was engraved on the face of the bracket proper. The elevation pointer was attached to the chassis, being movable and could be set by means of a scale to make elevation corrections of a semipermanent nature. Azimuth circles were always provided with a movable pointer and a scale permitting of a considerable definite movement on either side of the normal. The degree and sixteenths thereof were used for all angular measure, horizontal and vertical. Electrical illumination of aiming and laying apparatus was always provided by means of very heavy but flexible and well insulated cables. Battery Deutchland was the only battery found to have electric motors for traversing and elevating. No telescopic sights were found, but every carriage was provided with a sight bracket. The use of ball bearings for traversing instead of conical rollers was noted. Other characteristic features of a mechanical nature which differed from the American practice are as follows:

All gears, pinions, racks, worms and worm-wheels are made sufficiently strong to withstand the shock of discharge without interposing a slipping device so common in all our traversing and elevating mechanisms.

The use of chains and sprockets on carriages for large guns is noticeable.

Girder construction for large gun carriages is used rather than large solid castings; plates and rivets are used wherever possible.

Duplicate installations are frequent.

Emplacements

All emplacements were built of reinforced concrete. Batteries located back of the shore line in rear of the dunes varied considerably with respect to arrangement and type. In some cases the magazines were adjoining the gun, but the universal practice was that the gun platform and floor of the magazine were on the same level. Some batteries had no traverse construction between the guns and, in those that were so designed the profile was low. The guns of Tirpitz and Kaiser Wilhelm II were arranged in line and equally spaced; the traverse between each gun and the flanking guns were also protected. A low parados was in rear of each gun. These batteries resemble very closely American Coast Defense practice in plan, with the exception of the location of magazines. Batteries Deutchland, Preussen, Hannover, Schlesien, and Oldenburg are examples of an entirely different plan and one which is totally foreign to anything to be found in the United States. The guns of these batteries were disposed in a regular manner, but were located in the corners of a rhomboid, with sides 400 m. × 150 m.

on the average. With such an arrangement all four guns could not be enfiladed, at least two guns could fire in all azimuths and the arc of fire when one gun blanked another is very small. Batteries Preussen and Hannover (Railway batteries) had absolutely no protection whatsoever. Deutchland and Schlesien had magazines so located as to afford some protection from enfilade fire. Battery Oldenburg is in a class by itself; each gun was separate and distinct. Adjoining each gun is a massive concrete structure which contains the magazines and quarters for the personnel. This was the only case where personnel and ammunition were in the same structure. A more detailed description will be found under the head of each battery concerned in Part II. The emplacements in the line of dunes were similar to American Coast Defense batteries in almost every respect, the principal points of difference noted were: no concrete blast slopes, no break between exterior and superior slopes, no broad expanse of concrete, the use of every means to camouflage position from overhead observation and very low traverses. The only mortar battery found consisted of four pits, one mortar in each; the walls of the pits sloped gently and were extremely low as compared with U. S. mortar emplacements. The average thickness of concrete used for overhead construction of magazines varied from 2 to 3 meters, this being sometimes augmented with sand. The side walls varied in thickness from ½ to 2 meters. No two battery emplacements were alike. It appeared as if each battery commander had designed his own emplacement. Because of many differences of interior arrangement, the system of ammunition supply from magazine to gun varied with the emplacement. No mechanical ammunition hoist was found except in the case of turret batteries. Ammunition for the smaller calibers was either carried by hand from the magazine to the gun or raised through a shaft connecting the magazine and gun platform. For the larger calibers, ammunition was served direct from the magazine on trucks sometimes running on rails, sometimes not. All magazines appeared to be dry.

Quarters

Shelters for personnel were found at all batteries, except Hannover, Preussen, and Schlesien. These shelters were usually made of heavy timber frames, sheathed and well waterproofed walls; some of the poorer structures were being replaced by con-

concrete. These structures were all well protected, dry, and comfortable. The plan varied as in the case of the emplacement. There did not seem to be any type plan that was followed. The interiors were most elaborate, having been completed at the expense of, and by looting, magnificent hotels and dwellings. Plates 1 and 2 will give some idea of the exterior appearance of shelters.

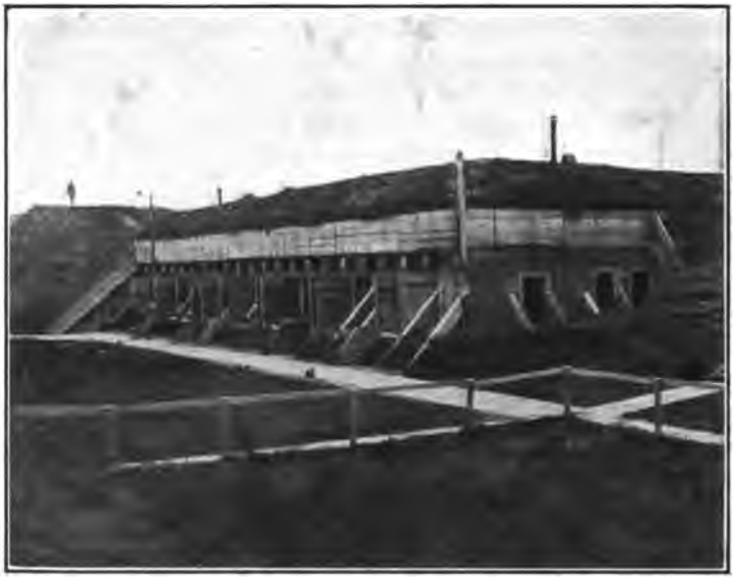

Plate 1 2319

Quarters for personnel belonging to a battle commander's station, (P. C. Weichel), interior finished in hard wood, comfortably furnished and electrically lighted. Heavy timber frame construction, sheathed and well waterproofed, about three meters overhead cover, sand and heavy timbers.

Stations

All P. C. and observing stations were of reinforced concrete and similar in plan to our own. The amount of overhead cover varied from one to two meters of concrete. The stations could not have been visible at any great distance from the front. Each P. C. was provided with self-contained horizontal base range finder which was mounted on the top or to the side of the station. There was every evidence that high power and very large observing instruments were used. In P. C. Weichel, a battle commander's station, a telescope at least four meters in length had been mounted; Plates 3 to 8 inclusive illustrate the general type of station used.

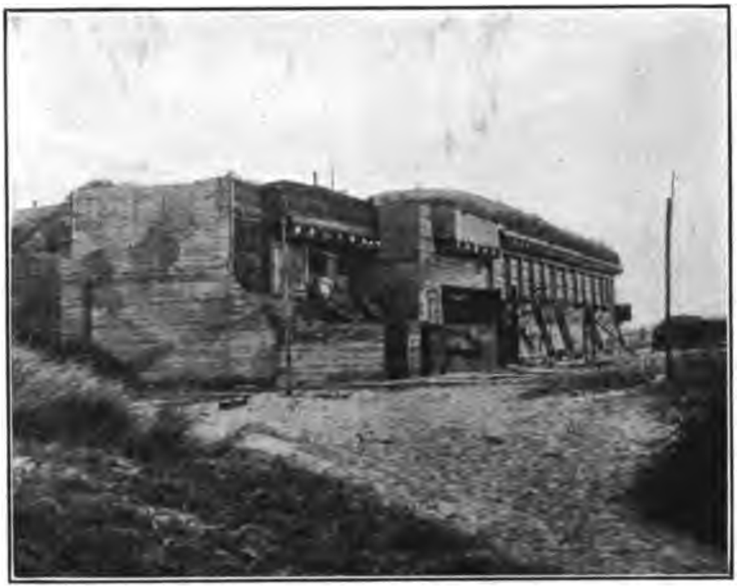

Plate 2 2320

Structure containing quarters for personnel, small power plant work and shop. Concrete and timber construction, about five meters overhead cover.

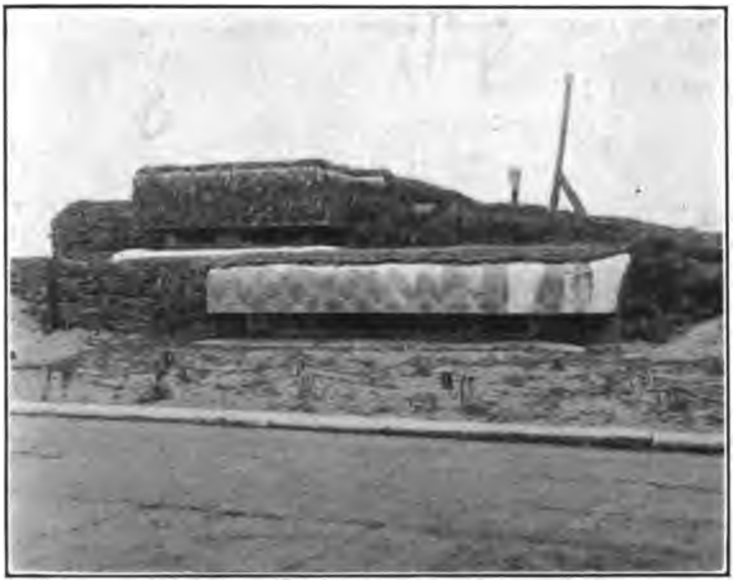

Plate 3 2321

A double station, one part being used as a P.C. and the other as an observing station. Note the camouflage and barbed wire. This station was very low, the sea boulevard can be seen in the foreground.

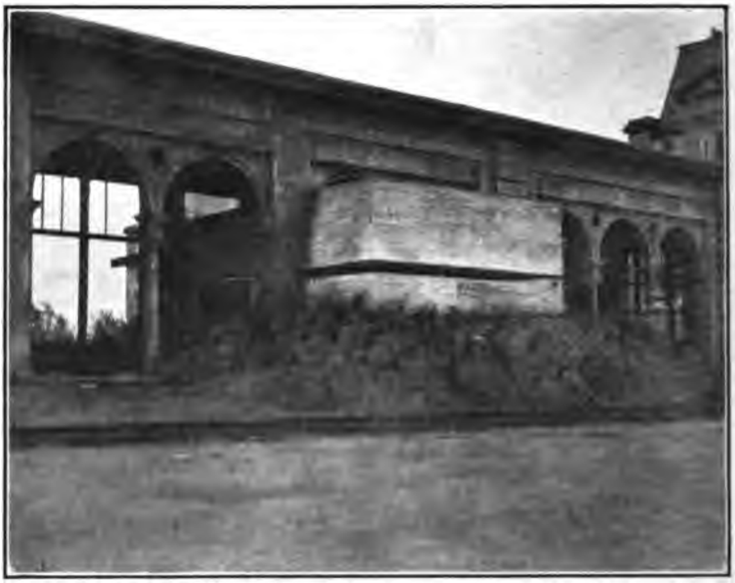

Plate 4 2322

A P.C. of reinforced concrete, concrete crow's-nest rising above roof of arcade contained a S.C.H.B.

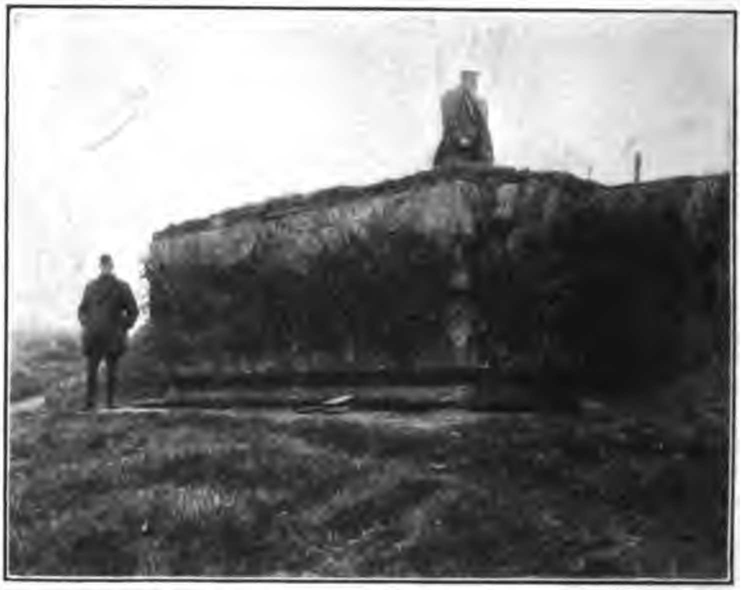

Plate 5 2323

An observing station of the South Ostende group, of interest because of the very thick roof. Reinforced concrete construction.

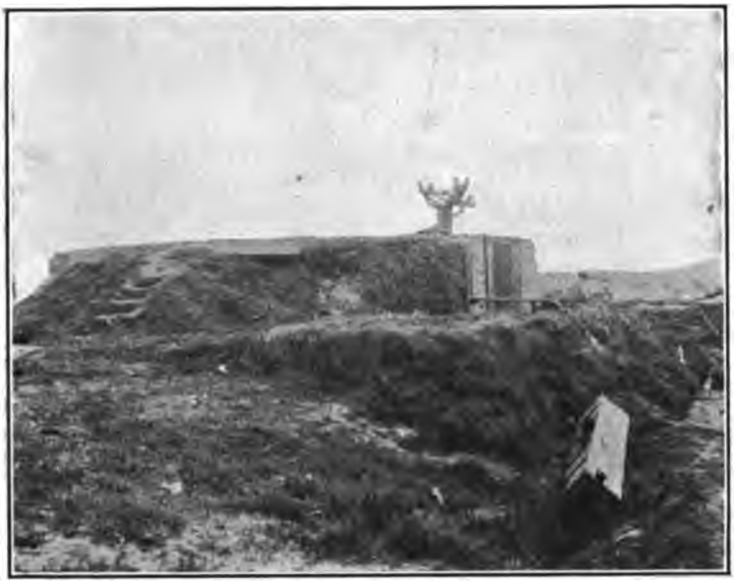

Plate 6 2324

Side and top view of a P.C. in the South Ostende group, giving an idea of the depth of the station and the most common location for the S.C.B.H.

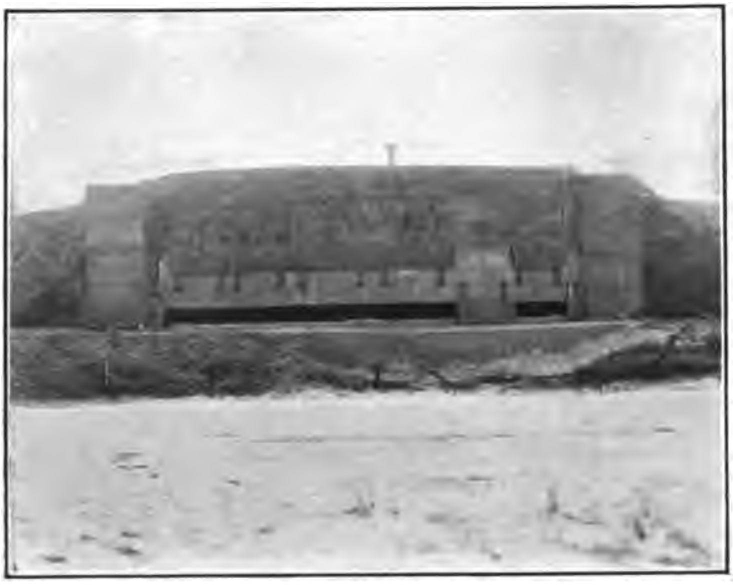

Plate 7 2325

Battle Commander's station (P.C. Weichel) South group, Ostende grouping. Very low elevation, sea boulevard in the foreground. The largest of any of the stations.

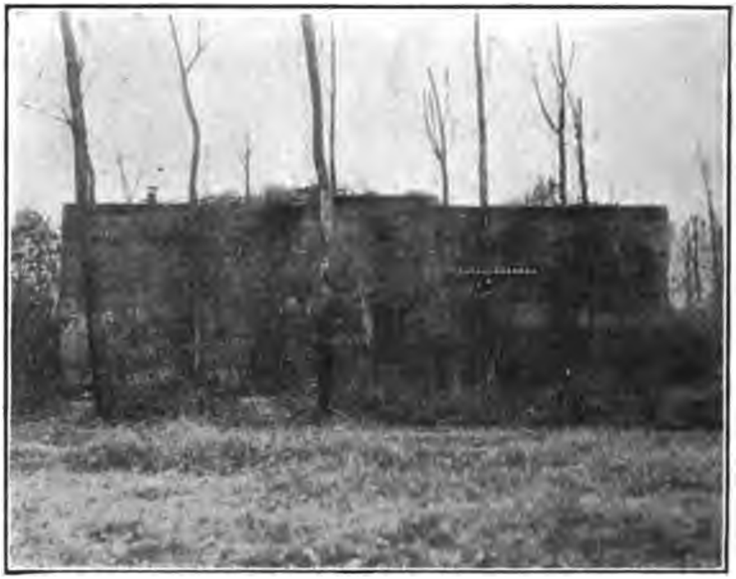

Plate 8 2326

P.C. of Leugenboom, the battery which fired on Dunkirk. Very massive reinforced concrete construction with very heavy iron doors in every entrance, interior and exterior.

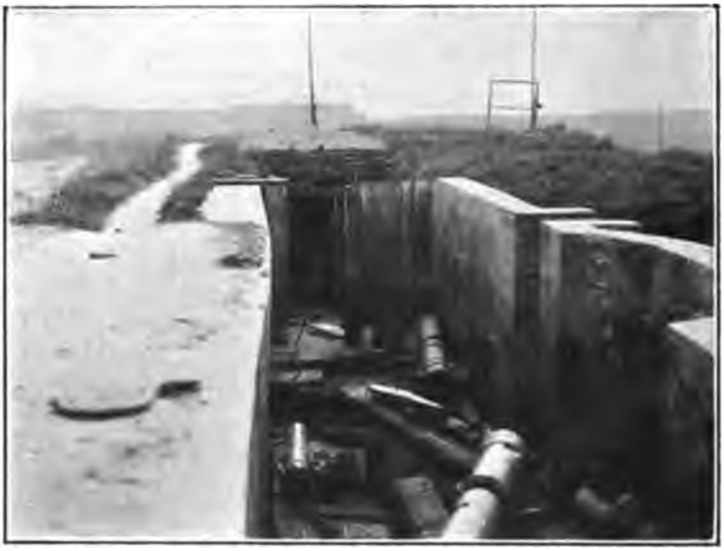

Plate 9 2327

View of the top and flank of a P.C. Notice the shelter for housing S.C.H.B. instrument when not in use. Pedestal was mounted on small truck running on a track. Remains of instrument in bottom of pit. A. A. machine gun mounted on truck directly in front of tunnel shelter.

Lookout stations were established in the tops of the highest buildings, and many towers were likewise occupied. The Palace Hotel located close to the shore was one of the highest buildings in Ostende. The plan of the Hotel was a square and at each corner a square tower rose several feet above the roof of the main building. The Germans raised the roof of one of these towers about one foot to provide an observing slot and occupied it as a lookout station. It was very well executed and could not be noticed at any great distance. In view of the fact that the remains of certain installations in these lookouts indicated position finding facilities, it is likely that spotting was done from these stations. Their location was always ideal for such purpose.

Several batteries had "data booths." These were located in such a position as to be plainly visible to all guns; Plate 10 shows such a booth.

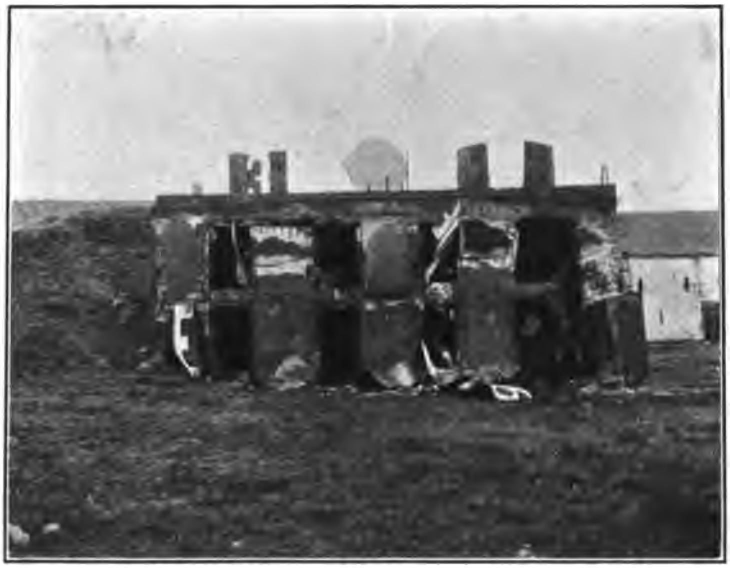

Plate 10 2328

Data booth, Battery Tirpitz, two tiers of figures painted on sheet metal drums, each drum independent, figures one meter high, two additional drums were located on the roof of the structure.

Searchlights

Searchlight installations were similar to the U. S. standard 60-inch searchlight. Searchlight shelters were very simple wooden structures just large enough to house the light. The lights were mounted on trucks with wheels running on rails. The power plant was removed, but at no very great distance from the light. No towers were used. The shelters found were always so placed that they faced due North regardless of the direction of the shore line. There was nothing unusual about the searchlight system found that would attract attention. The method of control could not be determined.

Power

The electric power system was extensive; that is to say, electric lights were provided everywhere. No standard plants seemed to exist; like everything else, no two units were alike.

Railways

Broad and narrow gauged railways were in evidence everywhere. It was possible to supply every battery with ammunition by rail from the dumps located well to the rear.

Ammunition

The ammunition found at the batteries would indicate that they were well stocked. Each battery had at least two types of projectiles. The long-nosed projectile was much in evidence, the radius of ogive in one case was as much as nine calibers.

Communications

Communication system was practically destroyed. The telephone system, however, was evidently adequate, all lines were run underground in cables, but not in ducts. The presence of speaking tube lines was common to all batteries and stations. The terminal stations could not be found, therefore, it was impossible to determine if a switchboard system was used or direct connected lines as used in the U. S. Coast Defense installations. Judging by other German telephone installations in permanent fortification it is likely that the switchboard system was used.

FIRE CONTROL

Instruments

The position and range finding system could not be determined with any degree of certainty. S.C.H.B. instruments were provided in great numbers. Each battery was provided with a 3-meter base and the battle commander with a 10-meter base instrument.

The remains of angle-measuring and observing instruments were found in abundance. Plotting boards of the German type were used, but these boards are much smaller than the Whistler-Hearn and are more in the nature of a simple mounting for a Plan Directeur to the scale of 1/20,000.

No evidence of a time interval system was found.

Plate 11 2329

Remains of a 10-meter S.C.H.B. belonging to Battle Commander South Ostende Group. Range finder located on the right flank of P.C. Weichel.

Position and Range Finding

The system of position and range finding used by the coast batteries must be deduced from the following evidence, which is all that remained, and from these considerations alone:

(1) The large number of S.C.H.B. instruments in open observing stations and command posts, indicating the assignment of one of these instruments to each battery and higher command.

(2) The assignment to each battery of the primary and intermediate armament of at least two observing stations located as far forward as possible and without any attempt to secure great height of site, the average height being only 8 meters above M.L.W.

(3) The remains of angle measuring instruments in some of the observing stations.

(4) The remains of plotting boards of a type identical with the field plan directeur artillery board.

(5) The existence of an elaborate system of inter-communication.

Plate 12 2330

Another view of the 10-meter base S.C.H.B.

Whether intersection by long horizontal base was the method employed for the determination of the range and azimuth of the target, or whether the initial range was obtained solely by the S.C.H.B. instrument is uncertain. It is fairly certain, however, that a system of tracking and prediction similar to our own was not employed with the plotting boards, the remains of which were discovered. These boards were simply 1/20,000 maps of the coast line and water area, pasted on a carefully prepared wooden back, with azimuth circles drawn for the various stations. One of the boards in fairly good condition was found to have five separate azimuth circles which were probably used as follows: one for the battery directing point, one for the B.C. station, and three for three separate observing stations. That these boards could be used for tracking the course of a moving target is not very probable, and their use simply as spotting boards might have been their sole function; if a more elaborate plotting board was employed, as seems likely enough in view of the fact that nearly all major caliber batteries used indirect fire exclusively, they were withdrawn by the Germans in their evacuation.

Assuming that the type of plotting board found is the only one adopted by the Germans for horizontal base, it would appear that the initial range and bearing were determined by its use. The speed and course of the target would be calculated by some other means than plotting. Trial fire would follow and adjustment secured by means of observation. All batteries of the primary armament, except one, used indirect fire. Most of the other batteries were so located that direct laying was possible. At every gun, reference data was painted on the shield. This data included range and bearing to important points and corrections to be applied under certain conditions. The azimuth pointer scales on guns compelled to use indirect laying at all times carried a rather complex table of figures conveniently mounted nearby. All this would indicate that the bearing of a set forward point was not sent to the guns, but rather the data of the last plotted position, together with the target's speed. At one battery the azimuth pointer mechanism had two settings, one horizontally and one vertically, the former depending upon the range used and the latter upon so many meters per second, probably the speed of the target. It is likely that successive plotted ranges and bearings were sent to the guns at regular intervals, but the evidence found does not indicate that the target was plotted and predictions made as in our own Coast Artillery practice.

GENERAL NOTES

Effects of Enemy Fire

The effects of enemy fire on the German batteries is worthy of mention and is of interest because of the fact there was no indication that a single gun had ever been put out of action. Battery Tirpitz probably received more shelling from the Naval forces than any other single battery and was also fired on by allied land batteries. There was plenty of evidence to show that this battery had been fired at for some time past, and the number of shell holes was too numerous to count. Fragments struck the guns and shields, and the emplacement also shows signs of being hit, but in no case was there any evidence of material damage being done. Apparently the other batteries of the primary armament were more fortunate, as few shell holes were found near them and, in the case of the R. R. batteries—Preussen and Hannover—not a single shell hole was found. There was nothing that would indicate that very much fire was directed against the batteries of the intermediate and secondary armament. Other elements of the coast defense, such as stations, power plants, etc. seem to have been untouched.

It seems remarkable that during a period of about four years that the fire from warships was able to do so little damage to the batteries. A great deal of destruction to buildings was, of course, very much in evidence.

Camouflage

The measures taken to secure concealment and prevent observation are not to be overlooked. Battery Oldenburg is one novel example of one of the mediums employed; camouflage screens and mats were used extensively, paint was used to some extent on concrete structures and guns, but probably the most effective of all means was the use of smoke. A great number of "smoke pots" were found and the indications were that they were used liberally and extensively along the entire coast and were capable of enveloping all batteries in smoke and in a very short space of time. These "smoke pots" generated a white smoke very rapidly and in great volume.

Due to the relative location of the batteries and observing stations, the existence of a smoke screen would not interfere with observation from the shore stations except when the wind was "off-shore."

Conclusions

From the study of the coast defenses made on the ground, the following conditions seem of paramount interest and importance:

(1) That all guns, regardless of caliber, had mounts which enabled them to use their full power, and secure maximum ranges that compare favorably with guns of similar type on battleships.

(2) That all heavy batteries were withdrawn from the coast and well separated from each other. No reference line for spotting, such as a shore line, was available to facilitate location of fire on the shore batteries.

(3) That each battery, regardless of caliber, was composed of four guns.

(4) That many of the batteries were so located that indirect fire was the only method of fire that could be employed.

(5) That the battery commander was apparently located in a B.C. station on the shore line and therefore at a considerable distance from his command, in the case of many of the most important batteries.

(6) That all observing stations were well concealed, and were strongly protected against hostile fire.

(7) That nearly every gun could fire on land as well as on water areas and in some cases, actually did so.

(8) That with the development of this system of defense, coast defense becomes the function of the batteries in contradistinction to a purely harbor defense purpose.

(9) That a large proportion of the armament installed is rapid fire, intermediate caliber guns.

(10) That there was only one battery of four mortars in the Coast Defenses.

(11) That each battery and each group of stations had its own anti-aircraft defense of machine guns.

(12) That a great many anti-aircraft guns were mounted in the defenses.

(13) That shields or turrets were used on nearly every gun in position.

(14) That great variety was permitted in the details of the installation, plan, and construction of batteries.

(15) That camouflage and concealment from aerial observation were carried to extremes, but the aeroplane photographs show that comparatively slight advantage was obtained by this means in preventing the detection of batteries during the period of construction.

(16) That heavy railroad guns were installed in a minimum of time to supplement the fixed defenses. Compare the three months required to prepare the emplacement for Battery Preussen with the year and a half necessary to build Battery Tirpitz.

(17) That the railroad guns and mounts were the only guns on the Belgian coast that were saved in the evacuation.

(18) Finally, that fire from hostile naval vessels, even when long continued did not effect the destruction of well located shore batteries.

* * * * To be continued * * * *

Astronomic Determination of Direction

By Captain Edward M. Burd, Coast Artillery.

(Continued from May Issue)

CIRCUMPOLAR STARS AT ELONGATION

Theory.—In a general way all fixed stars are circumpolar stars, but by usage the term is applied to those stars which are within about 20 degrees of the pole, (either pole), their paths apparently being concentric circles about their respective poles and completely visible from any latitude higher than 30 degrees. These stars could be used for Altitude Method observations just described, but more precise results are obtained by making use of a special case of this Altitude method, using the point of elongation of each star path, which is the point apparently diverging farthest from a north and south line.

The engineer's transit assumed to be used for observing is so constructed that, when in adjustment, any movement of the telescope alone generates a vertical plane of sight passing through the observer's position and the center of the Earth. Such a plane will be tangent to the path of any circumpolar star at its two points of elongation. For an infinitely small orbit these two points would be diametrically opposite and equally spaced as regards time. For larger orbits the points of tangency are closer together and on the upper side of the path, equally divergent from a north and south line, and the time elapsing from east elongation to west elongation is less than from west elongation to east elongation. For still larger orbits, or as the observer's latitude increases, the points of elongation move toward each other more rapidly until they meet at the zenith, which is the limiting case.

An observation taken at any of these times of elongation could be solved by the altitude method but with only indifferent results due to poorly shaped triangles and poorly defined vertical angles. But tables may be prepared as the result of purely theoretical computations, giving the azimuth of the vertical plane from observer to elongation of any star for any latitude and time of the year. These azimuths of elongation change but slowly for variations of time, but change with increasing rapidity as the latitude of the observer increases. For this reason the computed tables of azimuth are rather local in their application, or else have large correction factors for non-tabular latitude of observation.

The good points of this method are, (a) the elimination of computation and (b) the provision for observation with the approximate precision of the Polaris elongation method on sufficient stars so that there may be an observation at frequent intervals of the night. Opposed to these apparent advantages are, (a) the difficulty and uncertainty of finding and identifying many of the dim stars which must be used in order to obtain an elongation every two or three hours, and (b) the limited application of the method to a range of latitude of only about 15 or 20 degrees, and (c) the need of special tables for this range of latitude.

Practical considerations.—The actual operations performed in using this method are as follows: (a) selecting one or two of the tabulated stars which elongate at the most convenient time for observation, (b) locating and identifying the star to be observed and pointing the telescope at it, (c) following the star until elongation, then dropping the line to the ground and marking it or else turning the horizontal angle to some permanent mark, (d) determining from the table or computing the azimuth of elongation and applying it to the mark set or the angle read to obtain true north. The problems attending each step will be discussed in turn.

(a) Selecting the star: for this purpose the stars used should be within 30 degrees of the pole, and preferably within 20, because of the appreciable errors in azimuth caused by relatively slight errors in latitude when using a star having a polar distance of no more than 30 degrees. In this case one minute error in estimating the latitude will cause 20 seconds error in azimuth. There are only about ten stars within this area at the North Pole and less at the South Pole which are visible to the naked eye even on a clear night, and they are grouped so that elongations may be from a few minutes to three hours apart. This situation should be studied before planning field work and advantage taken of the elongations occuring near the desired time of observation. This requires that in addition to a special table of azimuths a table giving times of elongation for the latitude of the observer must be prepared or otherwise made available. The time must be estimated with care, as stars more distant from the pole than Polaris do not apparently remain at elongation for about 20 minutes, like Polaris, but approach and leave the tangent line more quickly. In estimating time for a non-tabular date do not interpolate between the times of east and west elongation, for they are not at opposite points of the orbit. If the star is a faint one, as is usually the case, additional note must be made of its azimuth from Polaris and its altitude at elongation in order to find and identify it. All this requires considerable familiarity with a Nautical Almanac or else the blind use of specially prepared tables covering all these points.

(b) Pointing to the star: Shortly before the elongation to be observed direct the telescope at the star. Even in clear atmosphere it will often be necessary to lay off the vertical angle and the azimuth angle from Polaris in order to do this. Several of the stars have near neighbors of only slightly less brightness, a confusing situation requiring the angles to be carefully laid off to be certain of the correct star. When its identity is established, follow it with the vertical crosshair until it ceases to move in azimuth, then mark the plane of sight on the ground or read the horizontal angle to some permanent mark. The star remains at elongation only a few minutes. A skillful observer may be able to take a reversed sight in the time available, but this second sight will be of questionable precision. If a check observation by this method is desired the next elongation may be taken, occuring probably an hour or two later. The star should be at least 20 degrees above the horizontal to be sufficiently free from haze, errors of refraction, etc. Above latitude 40 the place of elongation of stars having a polar distance of 20 degrees is too high to be observed with ease, and the instrumental errors of adjustment become appreciable, especially for only one pointing.

(d) Determining true north: Having marked the direction of elongation on the ground or read the horizontal angle to a mark, true north is obtained by finding the azimuth of the observed elongation from the table or computing it, and combining it with the data established during observation. This part may be done when convenient.

During the time consumed in making the 28 other star

RESULTS OF COMPARATIVE OBSERVATIONS FOR DETERMINING Y-AZIMUTH OF A LINE.

METHOD		OBS. NO.	TIME, DATE, STAR, ETC.	Y-AZIMUTH TO MARK ON LINE.	AVERAGE Y-AZ. OF GROUP.	DEVIATIONS EACH	DEVIATIONS MEAN	TRUE Y-AZ.	ERRORS EACH	ERRORS MEAN	REMARKS
EQUAL ALTITUDES OF STARS			No observations made; time element very inconvenient, requiring at least four hours between observations.								
EAST AND WEST STARS, ALTITUDE METHOD.		8	12/4 P.M., Aldebaran (E), 2 pointings	338° 45' 55"		+ 0' 1"			+ 15"		East stars were over the ocean, while West stars were over land, probably causing variation in the refraction correction which would introduce small errors in the computations.
		17	12/16 P.M., Betelgeuse (W), 2 "	46' 1"		+ 0' 6"			+ 21"		
		18	12/16 P.M., Fomalhaut (W), 2 "	45' 4"		− 0' 51"			− 36"		
		30	12/16 P.M., Procyon (E), 2 "	45' 56"	338° 45' 55"	+ 0' 1"	18"		+ 16"	25"	
		46	1/6 P.M., Procyon (E), 2 "	46' 10"		+ 0' 15"			+ 30"		
		47	1/6 P.M., Deneb (W), 2 "	46' 36"		+ 0' 41"			+ 56"		
		48	1/6 P.M., Procyon (E), 2 "	45' 45"		− 0' 12"			+ 5"		
CIRCUMPOLAR STARS AT ELONGATION.		16	12/16 P.M., δ Cephi, E. elong., 1 pointing	338° 45' 31"		+ 0' 6"			− 9"		Only three visible elongations occured during time of all other star observations
		19	12/16 P.M., β Cephi, W. elong., 1 "	45' 45"	338° 45' 25"	+ 0' 20"	18"		+ 5"	18"	
		38	1/4 P.M., β Cephi, W. elong., 1 "	44' 56"		− 0' 27"			− 46"		
POLARIS	ELONGATION		Occured about midnight during time of observations. Established standard method of proven precision.								
POLARIS	CULMINATION		Too dependent upon absolutely correct time to be dependable. No observations taken.								
POLARIS	ANY HOUR ANGLE	5	12/4 P.M. 1 pointing	338° 45' 44"		− 0' 11"			+ 4"		All observations taken near culmination, at which place errors in time are most serious.
		6	12/4 P.M. 2 "	46' 06"		+ 0' 11"			+ 26"		
		7	12/4 P.M. 1 "	46' 16"		+ 0' 21"			+ 36"		
		27	12/16 P.M. 2 "	45' 35"		− 0' 20"			− 5"		
		28	12/16 P.M. 2 "	45' 47"	338° 45' 55"	− 0' 8"	11"		+ 7"	16"	
		29	12/16 P.M. 2 "	45' 49"		− 0' 6"			+ 9"		
		44	1/6 P.M. 2 "	46' 05"		+ 0' 6"			+ 25"		
		45	1/6 P.M. 2 "	46' 04"		+ 0' 9"			+ 24"		
		49	1/6 P.M. 2 "	45' 55"		− 0' 5"			+ 15"		
POLARIS	PICKERING ATTACHMENT	20	12/16 1 pointing, near upper cul.	338° 46' 20"		+ 0' 48"			+ 40"		All observations taken near culmination, at which point the method is probably most severely tested.
		21	12/16 1 " " " "	45' 10"		− 0' 22"			− 30"		
		22	12/16 1 " " " "	43' 40"		− 1' 52"			− 2' 0"		
		23	12/16 1 " " " "	44' 20"		− 1' 12"			− 1' 20"		
		24	12/16 1 " " " "	45' 30"		− 0' 2"			− 10"		
		25	12/16 1 " " " "	45' 50"	338° 45' 32"	+ 0' 18"	40"		+ 10"	39"	
		26	12/16 1 " " " "	45' 55"		+ 0' 23"			+ 15"		
		39	1/4/19 1 " " " "	45' 40"		+ 0' 8"			0"		
		40	1/4 1 " " " "	46' 10"		+ 0' 38"			+ 30"		
		41	1/4 1 " " " "	44' 55"		− 0' 37"			− 45"		
		42	1/4 1 " " " "	46' 10"		+ 0' 38"			+ 30"		
		43	1/4 1 " " " "	46' 40"		+ 1' 8"		Adjusted Mean = 338° 45' 40"	+ 1' 0"		
SUN	EQUAL ALTITUDE		No observations made.								
SUN — ALTITUDE METHOD	IMAGE OF SUN BROUGHT TANGENT TO IMAGE OF CROSS-HAIRS.	1	12/3 P.M. 4 pointings; altitude 11°	338° 45' 21"		+ 0' 10"			− 19"		
		2	12/4 A.M. 4 " " 25°	43' 49"		− 1' 22"			− 1' 51"		
		57	1/6 P.M. 4 " " 19°	45' 48"	338° 45' 11"	+ 0' 37"	37"		+ 8"	39"	
		61	1/11 A.M. 4 " " 20°	45' 05"		− 0' 6"			− 35"		
		62	1/11 A.M. 4 " " 21°	45' 56"		+ 0' 45"			+ 16"		
SUN — ALTITUDE METHOD	CENTERING THE IMAGE OF SUN ON IMAGE OF SPECIAL CROSS-HAIR RETICLE.	9	12/5 P.M. 2 pointings; alt. 10°	338° 46' 42"	Average of all [illegible] A.M. obs. = 338° 44' [illegible] " " " P.M. " = 338° 46' [illegible] Greatest discrepancy: A.M.-28"; P.M.-30"	+ 1' 50"			+ 1' 2"		All solar observations were taken under most adverse conditions. The altitude at noon being only 30°, all observations were of necessity made at a low altitude, and the consequent large refraction correction was considerably affected by the water area to the east. Also, the astronomical triangles were poorly shaped: all being unavoidable defects of this method.
		10	12/5 P.M. 2 " " 9°	46' 22"		+ 1' 30"			+ 42"		
		11	12/26 A.M. 4 " " 24°	43' 13"		− 1' 39"			− 2' 27"		
		12	12/26 A.M. 2 " " 25°	43' 52"		− 1' 0"			− 1' 48"		
		13	12/26 A.M. 2 " " 28°	43' 04"		− 1' 48"			− 2' 36"		
		14	12/26 P.M. 2 " " 9°	45' 39"	338° 44' 52"	+ 0' 47"	62"		− 1"	67"	
		15	12/26 P.M. 2 " " 10°	45' 42"		+ 0' 50"			+ 2"		
		31	12/28 A.M. 6 " " 19°	44' 02"		− 0' 50"			− 1' 38"		
		32	12/28 A.M. 2 " " 20°	44' 54"		+ 0' 2"			− 46"		
		33	12/28 A.M. 2 " " 21°	44' 31"		− 0' 21"			− 1' 9"		
		56	1/6 P.M. 2 " " 20°	45' 33"		+ 0' 41"			− 7"		
SUN — ALTITUDE METHOD	DIRECT VISION; SUN TANGENT TO CROSS-HAIRS.	36	12/30 A.M. 4 pointings; alt. 18°	338° 43' 59"		− 1' 46"			− 1' 41"		
		51	1/6 P.M. 4 " " 34°	47' 12"		+ 1' 33"			+ 1' 32"		
		52	1/6 P.M. 4 " " 23°	46' 28"	338° 45' 39"	+ 0' 49"	78"		+ 48"	78"	
		50	1/6 P.M. 4 " " 23°	47' 10"		+ 1' 31"			+ 1' 30"		
		63	1/11 A.M. 4 " " 23°	44' 31"		− 1' 8"			− 1' 9"		
		64	1/11 A.M. 4 " " 26°	44' 39"		− 1' 0"			− 1' 1"		
SUN — ALTITUDE METHOD	DIRECT VISION; CENTERING.	34	12/30 A.M. 2 pointings; alt. 16°	338° 44' 02"		− 1' 15"			− 1' 38"		
		35	12/30 A.M. 2 " " 17°	43' 50"		− 1' 27"			− 1' 50"		
		37	12/30 A.M. 2 " " 25°	44' 31"		− 0' 46"			− 1' 9"		
		53	1/6 P.M. 2 " " 22°	46' 17"	338° 45' 17"	+ 1' 0"	69"		+ 0' 37"	69"	
		54	1/6 P.M. 2 " " 21°	46' 18"		+ 1' 1"			+ 38"		
		55	1/6 P.M. 2 " " 20°	46' 43"		+ 1' 26"			+ 1' 3"		
SUN — ALTITUDE METHOD	SOLAR TELESCOPE ATTACHMENT	58	1/10 A.M. 1 pointing; alt. 20°	338° 52' 0"	Results too erratic and approximate to be considered						
		59	1/10 A.M. 1 " " 20°	50' 0"							
		60	1/10 A.M. 1 " " 20°	52' 30"							
SUN	HOUR ANGLE.	57	1/6 P.M. 4 pointings; alt. 19°	338° 47' 55"		+ 1' 46"			+ 2' 15"		
		62	1/11 A.M. 4 " " 21°	43' 52"		− 2' 13"			− 1' 48"		
		15	12/26 P.M. 2 " " 10°	47' 10"	338° 46' 5"	+ 1' 5"	108"		+ 1' 30"	113"	
		56	1/6 P.M. 2 " " 20°	47' 45"		+ 1' 38"			+ 2' 5"		
		64	1/11 A.M. 4 " " 26°	43' 47"		− 2' 18"			− 1' 53"		

Bsd. Jan. 8, 1919.

All observations and computations made by Capt. Edward M. Burd, C.A. at Ft. Monroe, Va., in Dec., 1918 and Jan., 1919, using Berger 4½" transit. Long. = 76° 18' 40" W.G. Lat. = 37° 0' 6" N.

Plate I

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observations listed on Plate I, only three visible elongations of circumpolars occured. These three were observed and computed. For precision the results are not as consistent as those of Polaris at any hour angle, and certainly do not approach the precision to be obtained by observations on Polaris at elongation. It was quite evident in making the observations that difficulty in quickly and easily identifying a star and pointing to it are pronounced disadvantages, liable to cause a lack of confidence, which in turn unconsciously induces a loss of dexterity and skill in handling instruments. This method, while apparently eliminating computation, actually necessitates the use of several special tables and correction factors. The precision obtained is in no way superior to that of Polaris at any hour angle. No saving of time is effected. In fact, half a dozen Polaris observations may frequently be made and computed while waiting for a second elongation to check the results of the first. The proposition is more limited to a zone of latitude than any other, and instead of using the most distinct and easily found stars, some of those used are difficult to find even in clear atmosphere, and are invisable in a haze which does not obscure the brighter stars.

Polaris at Elongation

Theory.—The use of the elongation of Polaris for azimuth does not differ in principle from that of any other circumpolar star, as just described, but due to the proximity of this star to the true north pole and to its easy visibility, most of the disadvantages of circumpolars are removed and greater precision is possible under ordinary conditions. There is no similar large star close to the south pole. At present the polar distance of Polaris is about 1 degree 7 minutes. Because of its being so close to the true pole that its relative motion is slow, it apparently remains at elongation for 15 or 20 minutes, allowing sufficient time for precise observation. The astronomical theory involved is a part of the general case outlined under East and West Stars, but computation of the azimuth at elongation is not necessary as every ephemeris contains tables giving these values, computed for all possible latitudes and for the slight variations in declination in the course of every year.

Due to the small polar distance of the star, variations of a few minutes in the estimated latitude of observation have but an insignificant effect upon the azimuth, so that with only an approximate knowledge of the latitude and without reference to time this method permits observations with all the precision which the manipulation of the instrument allows. Hence it is frequently referred to and generally considered to be the most precise method of transit observation.

Practical Considerations.—The processes involved in making this observation may be divided into the following steps: (a) estimating the time of elongation; (b) sighting on the star and following it to elongation; and, (c) determining true north from the observed point of elongation.

(a) Estimating time of elongation. Whenever an ephemeris of any kind is available it will be found to contain a table giving the times of elongation of Polaris. In the absence of an ephemeris of any kind one may closely estimate the time at which it will occur by the positions of the stars near the pole, as will be described under (b), or the time of west elongation may be estimated from the following approximate description of its movement. About the middle of January west elongation occurs at midnight, then becoming 4 minutes earlier each successive night until it occurs about the middle of April at 6:00 P. M., noon during the middle of July, and 6:00 A.M. the middle of October. East elongation will always be very nearly twelve hours different. This means that during the winter months the night elongation comes at inconvenient times, while during the summer months (April, May, and June) both elongations occur before it is entirely dark. This matter of inconvenience is the only defect of this method. With a good transit the star may be located in the day time by laying off the direction and elevation to it, while at dusk it is sometimes even more easily followed than when entirely dark, as there still remains light enough to make the crosshairs visible.

(b) Sighting on the star. While the other circumpolar stars are rather dim, Polaris is bright, stands alone, and is easily identified. The elevation of the star above the horizontal is the same as the latitude of the observer. This altitude, with even an approximate compass north, will locate the star. Another way is to extend the line of the two outer stars of the bowl of the Big Dipper, from the top of the bowl, about five times the distance between the stars, to Polaris. On a clear night Polaris can be seen to be the end star at the handle of a very similar, but smaller, Little Dipper. Almost directly beyond Polaris from the Big Dipper and about the same distance away is the five-star constellation in the form of a letter W, with the top toward Polaris, the brightest star being the final one of the W. These witness stars easily locate Polaris at any time of the year. The position of the true pole with reference to Polaris, which will indicate the approximate time to an elongation, may be closely estimated by remembering that the true pole is practically in the line between Polaris and the star at the end of the handle of the Big Dipper. As the end star of the Big Dipper handle approaches a position due west of Polaris the latter is approaching eastern elongation, and vice versa. This will give a close approximation to the time of elongation.

South of Lat. 20 N. Polaris is too low for general use, but from Lat. 20 N. to 45 N. it is easily observed. For higher latitudes the usual type of transit construction does not permit direct observation, errors due to lack of adjustment of the instrument rapidly increase in magnitude, and the use of this method is generally unsatisfactory, so that its zone of usefulness may be said to lie between latitudes 20° N. and 45° N. The southern hemisphere is not so fortunately favored with a bright star approximately at the pole.

Having pointed the vertical crosshair at the star perhaps 20 minutes before the scheduled time of elongation, follow the star with the vertical hair until it apparently ceases to move in azimuth. At east elongation it will appear to be ascending the vertical hair for about 15 minutes and then start moving slowly back in azimuth. At west elongation it will behave similarly, moving downward. During this 15 minutes that the star is apparently stationary in azimuth several pointings to it may be made. In latitude 40° the azimuth changes only about one minute during the half hour preceeding or following the elongation, and practically all of that azimuth motion occurs in the last third of that half hour since the movement varies as the square of the time from elongation. In making the observations, the angle from star to mark may be read, but a more satisfactory way is simply to depress the telescope from the pointing at the star and mark the line on the ground, making pointings with the telescope both direct and inverted. The marks established by this set of two pointings need not necessarily agree exactly; the difference is due to the errors of adjustment, largely, and the average should be used. There will usually be time for a second or even a third set of pointings. The more carefully made pointings the better, for the precision attainable by this method is only limited by the dexterity with which the telescope may be pointed at the star and the lines marked upon the ground. At any later and more convenient time the true north line may be laid off from the line to elongation established on the ground.

(c) Determining true north by laying off the azimuth angle may be done either with the transit, using the repetition angle method, or by laying off the tangent of the angle with the tape. The value of the azimuth angle may always be found in any ephemeris. In the absence of an ephemeris the angle may easily be computed from the following relation:

$$\text{sine of az.} = \frac{\text{sine of polar distance}}{\text{cos of latitude of observation.}}$$

The polar distance (90° — the declination) is slowly decreasing about 15″ per year, through a cycle which for 1919 is represented by the following critical points; Feb. 1, p.d. = 1° 7′ 14″, then increasing to 1° 7′ 46″ at the end of June, then decreasing to 1° 6′ 58″ at the end of Dec. At any time of the year a close approximation may be made, probably within 10 seconds, giving a result well within the probable precision of the instrument work. An error of one minute in the latitude only causes an error of one second in the azimuth angle. For most purposes it will be sufficiently precise to compute the azimuth in seconds by dividing the polar distance in seconds by the cosine of the latitude. Thus, for an observation at Lat. 40°, made on April 1, 1919 the azimuth at elongation would be,

$$\frac{1^\circ\ 7'\ 30''\ \text{(estimated)}}{\cos 40^\circ} = \frac{4050''}{.76605} = 5285'' = 1^\circ\ 28'\ 5''$$

The ephemeris gives the declination for April 1, 1919 as 88° 52′ 33″, from which the polar distance would be 1° 7′ 27″. For the indicated declination the azimuth angle in Lat. 40° is given by the ephemeris as 1° 28′ 3.2″, showing that the approximate method gives all precision needed for any work with a transit.

Careful consideration indicates that the time element—waiting for an elongation—is practically the only unfavorable criticism of this method between Lat. 20° N. and 45° N. The entire observation and the laying out of the true north and south line may be made without any tables or information other than a knowledge of the principles outlined in this discussion, and with as great a precision as desired. Observation is easy, no angles need be read at night, and but little knowledge of astronomy is required.

POLARIS AT CULMINATION

Theory.—A vertical plane through the observing instrument and the true north pole is intersected by the path of Polaris at the points of culmination. Hence if the star be followed with the vertical crosshair of the telescope until it is at a point of culmination, the line of sight will lie in a true north and south plane. To determine the point of culmination the mean local time at which it will occur at the longitude of the observer must be obtained, usually from an ephemeris. The relation between the mean local time and watch time, standard time, must then be known, and the star is followed until the computed watch time of culmination occurs, when all azimuth motion is stopped and the line of sight is presumably pointing true north.

Practical Considerations.—The procedure is as follows: (a) computing the watch time of culmination; (b) following the star until the indicated time, and (c) establishing the north line on the ground.

(a) Watch time of elongation. Any ephemeris will give the time of culmination, usually the upper culmination, for each day of the year. The lower culmination may just as well be used, and the time of it will be 11 hours 58 minutes different from adjacent upper culmination. Usually the ephemeris will give this in mean time, at Greenwich, which is standard time at 0° Longitude. If given in apparent time the equation of time must be applied to obtain mean time. The mean local time of this culmination at the place of observation must then be computed. It will be a matter of a few minutes earlier than at Greenwich, the difference being that proportional part of 4 minutes represented by the ratio of the longitude of the observer west from Greenwich to 360 degrees. Applying this correction to the ephemeris time gives the mean local time of culmination at the point of observation. The difference between this time and standard time will be 4 minutes times the difference of longitude of the central meridian of the time belt in which the observer is located, and the longitude of the observer. Mean local time will be this amount earlier if the observer is west of the central meridian, and later than standard time if the observer is to the east. Applying this difference will give the standard time of culmination. If "daylight-saving" time is used allowance must be made for this also. (b) Having computed this time data, and having a watch set to standard time, the star should be followed with the vertical hair of the telescope until the indicated time, azimuth motion stopped and the line of sight marked on the ground. There will be no time to take a reversed sight, as the star is moving in azimuth at the rate of one minute of arc in three minutes of time. Hence care in the calculation and the calling of time are essential. This limitation of the whole observation to one sight, which in itself cannot be made with the precision of a pointing on a stationary object, rather casts suspicion, or at least gives a feeling of uncertainty and lack of confidence, upon the one pointing obtained. If any slip of manipulation of the instrument should occur, or the crosshairs not be sufficiently illuminated at the exact time, or any one of a number of the usual unexpected but ever-present circumstances arise, the entire observation is liable to be a complete failure.

(c) If the observation is successful in every way the telescope will be pointing true north, and a point may be permanently marked on the ground. This part of it is simple. While in theory the method is plausible, in practise it is found to be of little value and very seldom used.

POLARIS AT ANY HOUR ANGLE

Theory.—Observations on Polaris may be made and the astronomical triangle solved according to the general case covering all fixed stars, as outlined under East and West Stars, Altitude Method. But because of the relatively small orbit of the star, tables may be prepared from the theoretical astronomy involved by means of which the azimuth of the star may be more easily obtained at any time without measuring the angle of elevation of the star, resulting in less computation and greater precision. This hour angle method is perhaps the most commonly used one between latitudes 20° N. and 45° N.

To an observer Polaris apparently travels counterclockwise along a circular path the center of which is the true pole. When the star is directly above the true pole, at upper culmination, its hour angle is arbitrarily said to be zero. An hour later it will appear to be about 20 minutes of arc west and slightly below its position at zero hour angle, and the star is then said to be an hour angle one. This convention of measuring the angular travel of the star by the elapsed time after upper culmination is continued until the point of lower culmination is reached, which point would have an hour angle of 11 hr. 58 min. 2 sec. since the star circuit is made in 3 min. 56 sec. less time than the mean solar day. As the star continues its motion on the second half of the orbit the hour angle is the angle measured clockwise from the point of upper culmination to the position of the star, so that the hour angle can never exceed 11 hr. 58 min. 2 sec., and is always measured from the *nearest* upper culmination.

In making an observation the horizontal angle between some mark and the star is measured and the time of observation is noted. By consulting an ephemeris of Polaris for the current year the time of the upper culmination nearest to the time of observation and the declination at that time may be obtained. This time of upper culmination will be given for some standard meridian, as Greenwich or Washington, D.C. In any case it must be corrected to give the time of upper culmination at the longitude of observation. This correction is the proportional part of four minutes (the star circuit is this amount shorter than the mean solar day) represented by the ratio, to 360°, of the difference in longitude of the place of observation and the standard meridian. That is, if the place of observation were 90° west of the standard meridian of the ephemeris, the time of upper culmination would be 90°/360° times 4 min. = 1 minute earlier at the place of observation than the time given in the ephemeris. This nearest upper culmination need not be on the same civil day as the observation. The difference in time between this nearest upper culmination at the place of observation and the actual time of observation, both in the same system of time —mean local time, usually—is the desired hour angle of Polaris. The three items now known are; hour angle and declination of Polaris at the time of observation, and the latitude of observation.

General hour angle tables are usually available in any ephemeris by means of which, knowing these three quantities, the azimuth of the star from the meridian at the time of observation may be determined by a triple interpolation, which constitutes practically all the computation necessary with this method. Having this azimuth angle and the angle from mark to star at the time of observation, properly combining the two gives the angle from the mark to the meridian.

This triple interpolation process is considered by some to be difficult to remember and unsatisfactory for only occasional use. It is but little more work to compute the azimuth angle, A, directly, knowing the three quantities just mentioned, as follows: convert the computed hour angle, in hours, minutes, and seconds, into degrees, minutes and seconds of arc by the ratio of 1 hour of time equals 15 degrees of arc. Then solve the following formula, which is not as formidable as it looks, for the azimuth angle, A.

$$\tan A = \frac{\text{sec lat.} \times \text{cot decl.} \times \text{sin hour angle}}{1-(\text{tan lat.} \times \text{cot decl.} \times \text{cos hour angle}).}$$
$$= \frac{\text{sin hour angle}}{\text{cos lat.} \times \text{tan decl.} - \text{sin lat.} \times \text{cos hour angle}}$$

Practical considerations.—The procedure to be carried out in making an hour angle observation consists of the following steps: (a) field work of observation, (b) computation of hour angle, and (c) computation of azimuth angle from mark to true north.

(a) Field work of observation. Means of locating Polaris and of approximately determining its position on its orbit are given in "Polaris at Elongation." Estimating the approximate hour angle will also help in roughly checking the proper sense and value of the computations. Some permanent mark, visible at night, should be selected and used as a reference point for all observations, from which the azimuth angle to the star will be read and from which the azimuth angle to true north will be computed. With the plates reading zero when the telescope is pointed at the mark, read the azimuth to the star, once with the telescope direct and once with it inverted. Then check back on the mark with the telescope still inverted. This constitutes a simple "set" of readings, and if performed with only reasonable care and with an ordinary transit the precision to be expected of the results is probably represented by the nine "sets" on Plate I, where the maximum error for two pointings amounts to 26 seconds and the probable error about 15 seconds. One "set" would represent the minimum amount of field work, to be made use of in case of haste, partial obscurity of the star, etc. Time permitting, more "sets" should be run, both for the additional precision of the average and as a check on the results to be used. When two or three "sets" are taken it is usual to average all the observed times and the observed angles and compute the azimuth for these averages. If the observations are fairly uniformly spaced over not to exceed fifteen minutes of time the slight curvature of the path, as differing from the straight line assumed when averages are used, will introduce an error of but a few seconds, appreciable for precise work, however. Neglecting the theoretical advantages of working each observation separately, it has its practical advantages in giving independent checks on the computations and in showing the deviations of the several "sets", from which a probable error may be roughly estimated. An occasional error in arranging the pointings for an observation by this method consists in taking twice as many pointings at the star as of angle readings to the mark, which is not necessary nor desirable, as the telescope can be pointed at the star with greater precision than the angle can be read, and any error in the latter enters the final result at its full value.

(b) Computation of the hour angle has already been covered.

(c) Computing the azimuth angle from mark to true north may be done in several ways, triple interpolation among the three variables being in common use. As usually arranged these tables set forth variations in hour angle under tabular values of declination, and adjacent thereto is tabulated the azimuth angles corresponding, for certain latitudes. The first interpolation is to determine bracketing values of hour angle for actual declination at the time of observation. This requires two simple interpolations, one between hour angles slightly greater than the computed one and one between hour angles slightly less. Then do two similar simple interpolations between tabulated values of azimuth angle corresponding to the bracketing values of hour angle which were used, for latitude at the place of observation, the interpolated azimuth angles being a bracket similar to the hour angle bracket. The computed hour angle lies within the latter bracket, and the desired azimuth angle lies within the azimuth bracket established, and the proportion is the same in each case. Computing the azimuth angle by this proportion, and applying it correctly to the angle read from mark to star in making the observation, gives the angle from mark to true north.

The interpolation is usually made in a table giving azimuth to minutes and tenths. For greater precision a solution of the formula would be required. Various tables arranged for interpolation between two of the unknowns, with a correction factor to be applied for the variations of the third, have been devised to take the place of the troublesome interpolation. Also, diagrams may be constructed from which by a certain procedure, the azimuth angle may be read directly. All these devices, like attachments to instruments, are labor saving devices which are mainly useful to those doing this work with sufficient regularity so that their use becomes second nature. If observations are infrequently made the uncertainty usually attending the manipulation of semi-mechanical shortcuts outweighs their advantages, and the computation of the formula direct is more satisfactory.

In general, it may be said that this method is well adapted to quick observation anytime that stars are visible, between latitudes 20° N. and 45° N., and may even be used in the daytime with a telescope of 25 dig., or more, power, with an object glass having an effective diameter of one and a half inches. A one "set" observation can be made in five minutes and computed in ten, with a probable error of 20 seconds or less, watch time being correct within a minute. Additional time and care will give greater precision, and the method is apparently adapted to any degree of precision, having frequently been used for primary triangulation in which direction is computed to a fraction of a second. On the average it appears to receive the most favorable consideration among standard engineering handbooks.

Harvard Attachment

(*Pickering Attachment*)

Theory.—As viewed from any point on the Earth, Polaris appears to move in a circle about the true pole. The radius of the circle is measured in angular instead of in linear units, and at present this polar distance is about 1° 7′. This means that at any point on the Earth an angle of 1° 7′ is subtended by the distance from the true pole of the celestial sphere to Polaris. In comparison with the distances to the stars any terrestrial distance is insignificant, and the difference in the position of the observer on the Earth will affect this polar distance only a fractional part of a second of arc.

Having this in mind, assume that the line of sight of a transit is directed toward the true pole, after which a glass prism is placed in front of the telescope. The prism will refract the line of sight, that is, bend it through an angle, the magnitude of the angle depending upon the optical design of the prism. Apparently the telescope will not now be pointed toward the pole, altho physically its position has not changed. If the prism changes the apparent direction of the line of sight by 1° 7′, the telescope will appear to be pointed at some point on the path of Polaris. If the prism is now rotated about the axis of the telescope, the apparent line of sight will travel along the path of Polaris, and eventually will meet Polaris, at which time the telescope will apparently be pointed at Polaris, altho if the prism be removed the line of sight will still be pointing to the true pole.

A working model of a prism attachment similar to this has been developed by Professor Pickering of Harvard University, in co-operation with the Coast Artillery School. The prism, simply a wedge shaped piece of glass, is set in a tube resembling a telescope sunshade, fitting closely the object glass end of the telescope, so that it may be rotated about the axis of the telescope. By turning the attachment into the correct position, and sighting the telescope upon Polaris, on removing the attachment the line of sight will be pointed at the true north pole. When in this correct position the axis of the prism (a line parallel to the thin edge of the prism) is perpendicular to the plane containing the observer, the true pole and Polaris. This requires that before making an observation the attachment must be rotated until the axis described is perpendicular to this plane.

At present the easiest way of meeting this requirement appears to be to line up, with Polaris and some other star, a short metal straight-edge rigidly attached to the sleeve containing the prism. The straight-edge is attached so that it makes the proper angle with the axis of the prism, which is a matter of astronomical computation. With this arrangement, the straight-edge is lined up with the stars chosen by rotating the attachment, with the proper star at its respective end on the bar. The crosshairs of the telescope are then directed at Polaris, the attachment carefully removed and the unrefracted line of sight established upon the ground, or the angle read to a reference mark.

Practical operation.—Numerous tests with the model give satisfactory results and indicate that it is easy to attach and manipulate, and not subject to most of the short-comings of attachments in general. Of the twelve trials listed on Plate I, the maximum error was two minutes and the average was forty seconds. The tests were made without using particular care, in order to determine what errors might be introduced by poorly lining the straight-edge and by placing and removing the attachment with varying degrees of dexterity. After putting it through these tests it appeared certain that, knowing the characteristics of the particular attachment, careful use should give consistent and dependable results, with a maximum error of one minute in any one pointing and a probable error of 20″ in the average of several pointings taken at different times of the night. Apparently the weak point of the present model is in the lining up of the straight-edge with the stars selected. Any light thrown on the metal edge obscures the stars and when the eyes are focused on the stars the edge does not stand out sharply. It is probable that a long, narrow slot, like the sighting slot of a surveying compass, might be easier to use. Errors or misjudgement in lining have their greatest effect when the star is near culmination, but on the other hand the effect of poor optical construction of the selection of the proper color, as described further along, are greatest near elongation. While the principle of reversion may be applied to the transit when the attachment is used, it cannot be applied to the attachment itself, so that the best way of compensating for errors of this kind seems to be to average the results obtained from observations on opposite sides of the meridian.

Mention was made in the preceding paragraph of knowing the characteristics of the particular attachment to be used. Like any other attachment there are liable to be slight defects of construction which should be known and allowed for, but even assuming perfect workmanship present indications are that the life of an attachment will be only a few years, due to the fact that the angle through which the line of sight is to be refracted is changing at a slow but rather uniform rate. The precession of the poles is causing a decrease in the polar distance of about 20″ per year, for the true pole is moving across the heavens counterclockwise in approximately a circle nearly sixty degrees in diameter, requiring about 25,000 years to complete the cycle. The change per year is about 50″. At present the pole is about 1° 7′ from Polaris and moving closer and in a little less than a century will be at the closest point, about 30′ distant. The Nutation of the axis takes place in a more or less regular cycle of 19 years duration, the maximum change in the cycle being nine seconds. The third variation of a magnitude is caused by the aberration of light due to the orbital velocity of the Earth. This results in a yearly cycle in the variations of the polar distance, and the stars near the poles are the ones most affected. As a result of these three variables of appreciable magnitude, and of several others having less effect, the declination of Polaris for the year 1919 varies from 88° 52′ 45″ down to 88° 52′ 16″ and then up to 88° 52′ 62″. All tables make provision for these variations and as an instrument of precision this attachment should do the same.

When viewed through the prism, Polaris appears as a thin spectrum about one minute in length, so that by a judicious use of the various colors of the spectrum at various times of the year, as might be determined by experiment and computation, allowance could be made for these variations up to the extent of one minute of arc, which would take care of several years changes in declination. This would then be the life of the attachment, unless some adjustment might be devised. But on an instrument of this type it is generally agreed that any possible movement of the prism would only lead to uncertainty, and any change in the refraction should be made by an instrument manufacturer only. Consequently, these instruments are hardly adapted to only intermittent use, by various observers, but would be extremely serviceable to anyone making frequent observations and fully understanding the characteristics of one particular attachment and the allowances to be made at any time.

SOLAR OBSERVATIONS—EQUAL ALTITUDES

Theory.—The principles involved are identical with those of the first method described, Equal Altitudes of a Star. Using this method with the sun is a special case in that an additional complication, due to the changing declination of the sun, is involved. By applying a correction for this factor, the method may be applied the same as for stars. The observation is similar, the total angle is bisected and then the correction is applied to the direction of the bisector, being a small computed angle determined as follows:

Note carefully the watch time of both A.M. and P. M. observations, not for exact time but in order to determine the elapsed time between observations as closely as possible. From an ephemeris for any year obtain the variation in declination, in seconds change per hour of time, for the time of the year the observations are taken. Multiply this value, in seconds, by the elapsed time between observations, in hours, calling the product "D". Convert *half* the elapsed interval of time between observations into equivalent degrees, minutes, and seconds of arc, calling it "P", the hour angle of the sun. Let "L" be the latitude of the place of observation. Then,

$$\text{correction angle} = \tfrac{1}{2} \times \frac{D}{\cos L \times \sin P}$$

If the sun is observed from a point to the north of it the bisector of the total angle will extend south of the observer. If the sun is moving to the north, true south is to the east (left) of the bisector of the angle, and vice versa.

Practical Considerations.—The easiest way of observing is to project the image of the sun onto a piece of white paper held several inches back of the eyepiece end of the telescope. If a colored eyepiece is available direct observation may be used, but probably with no better results. Rather than try to center the sun on the crosshairs, bring the horizontal hair tangent to the lower edge of the sun's disk or image, and keep it there with the slow motion screw until the sun has moved tangent to the vertical crosshair. Then read and record time, vertical angle and horizontal angle. When the sun approaches the same altitude in the west, follow it in azimuth with the vertical crosshair tangent to the image, but on the opposite side from the morning observation, keeping the instrument set at the same angle of elevation as was read in the morning. When the lower edge of the sun's image comes tangent to the horizontal hair stop all motion of the instrument and read and record time and horizontal angle and check the vertical angle. Then compute the correction and apply it to the bisector of the total horizontal angle included between the A. M. and P. M. observations.

For good observation the sun should be changing about as rapidly in elevation as in azimuth. Several observations at convenient variations of altitude may advantageously be taken the same day, so as to obtain an average and more precise result. Using the telescope direct in the A. M. and reversed in the P. M. will largely eliminate errors of adjustment. Altho requiring a considerable part of the day this method will give better results than either of the following more commonly used ones.

Solar Observation—Altitude Method

Theory.—This method is only a special case of the general altitude method outlined in the second part of this discussion, called, East and West Stars, Altitude Method. The three sides of a spherical triangle are obtained either from observation or from tables, and having these three sides the angles may be computed. This special case differs from the general case in that one of the sides, the polar distance of the sun, is not nearly constant in value but is changing at a variable rate, requiring the use of the time of observation in order to compute its value at the instant of observation. This change in polar distance varies from sixty seconds per hour in March and September to nothing in June and December, and errors in the time of observation will result in errors in the data of observation in this proportion.

This polar distance is equal to 90° plus or minus the declination tabulated in an ephemeris, plus if the sun is south of the equator and minus if it is north. The declination is listed for some standard meridian and at a certain time, usually noon. The hourly change is also given. The actual difference in time between the time of observation and noon at the standard meridian must be computed, from a knowledge of the difference of longitude of the two places and the recorded time of observation, remembering to allow for the difference between mean local time and standard time and (daylight-saving) time, if used. Having computed this difference, multiply it by the tabulated difference in declination for one hour of time and apply the product, with the correct algebraic sign, to the tabulated declination for the day at the standard meridian. The result will be the actual declination at the time of observation, and combining this properly with 90° will give the polar distance, one of the three sides of the triangle. The other two sides are obtained as previously explained under East and West Stars.

Having these three sides the angle "A" at the observer measured from true north to the sun is computed by either one of the following formulas:

$$\tan \tfrac{1}{2} A = \sqrt{\frac{\sin (S\text{-lat}) \times \sin (S\text{-alt})}{\cos S \times \cos (S - \text{polar dist.})}}$$

$$\cos \tfrac{1}{2} A = \sqrt{\frac{\cos S \times \cos (S - \text{polar dist})}{\cos \text{lat.} \times \cos \text{alt.}}}$$

In making the observation the horizontal angle was measured from some convenient permanent mark to the sun. The angle "A" here computed is the angle from true north to the sun. Properly combining these two angles gives the angle from the mark to true north, which is the desired angle, by means of which a true north and south line may be laid out upon the ground, or the true azimuth of any line computed.

Practical Considerations.—Before making an observation by this method there are many considerations which should receive attention in order that the work may be done as quickly as is consistent with the precision required, and in order that all parts of the procedure may be carried out with the same relative care and precision. This method is not generally considered to be as precise as star observations, which is no doubt true, but by giving each part sufficient thought greater precision may be attained than is commonly believed. Various authorities make statements to the effect that solar observations have a probable error of from one to two minutes. Single observations probably do, but an average of several well planned ones should give a result well within a minute, and in view of the ease and convenience of making the observations in connection with field work it is worth while making the most of the method, and using it when possible. These points may be grouped under three heads as follows: (a) selecting the time for observation, (b) methods of observing on the sun, and (c) the desirable number and sequence of pointings.

(a) Selecting the time for observation. Of the three sides of the triangle to be solved, the polar distance will probably be the one known with the greatest precision. Next will come the latitude, as that can usually be obtained from a large scale map well within a minute. No map of this class being available, observations should be made for latitude. The side which will probably contain the inaccuracies is the one obtained by measuring the vertical angle, or altitude. Refraction is often uncertain, the parallax correction altho not usually made enters in here, the vertical circle of the usual transit is a much less reliable part than the horizontal circles, as it is smaller, less easy to read, the index more liable to be slightly misplaced, the reading edge injured, etc. For these reasons it is desirable to have our astronomical triangle of such shape that errors in the altitude side will have the least effect on the angle of the triangle at the observer. Having a right angle at the sun most nearly meets this requirement. Due to the spherical excess, this will mean almost as large an angle at the observer. Other things being equal, observations should be planned at a time when a triangle of this form may be had, or else the situation must be faced by taking additional vertical angle readings with all possible care. In the United States the form of the triangle is particularly bad in the winter, as shown by the results on Plate I. All these figures were elongated and sensitive to slight errors in the altitude side, which probably accounts for part of the consistent difference of the A. M. and P. M. observations. Under these conditions the precision of the results of summer observations cannot be expected, but by averaging A. M. and P. M. results a fairly close determination may be made.

It is also desirable, because of this difference in the ease in reading horizontal and vertical angles, to observe at a time when the sun is moving at least as fast in altitude as in azimuth. In this respect also winter observation is unfavorable to precision. Refraction is another element which plays a large and, unfortunately, variable part in the altitude measurement. Below an elevation of 15 degrees satisfactory observations are the results of chance. This is another obstacle to winter observations in the temperate zones, for at this latitude, 37° N., the sun is only 30° high at midday, and to obtain an observation far enough from the meridian to be of any value it must be made at a lower altitude than is desirable. Because of all these difficulties solar observations in the temperate zones in the winter should be made only as checks on previous work, and rarely may be depended upon for consistent precision within a minute. But in the tropics, or in the higher latitudes in the summer, the physical conditions should permit of reliable solar work comparable with star observations as regards precision of results, and much more convenient for field work.

(b) Methods of observing on the sun, will usually come under one of the following four methods, depending upon the use of a colored glass eyeshade or prism and the construction of the crosshair reticle.

1. The image of the sun may be brought tangent to the crosshairs, in one of the four quadrants at a time, by focusing the image upon a piece of white paper or a commercial ground-glass screen, held a few inches in rear of the eyepiece end of the telescope. At the same time the crosshairs will need to be focussed, also, usually by extending the eyepiece sleeve as far

as possible. In this way both the image of the sun and the shadow of the hairs will stand out sharply, and by using the slow-motion screws the sun may be placed tangent to the crosshairs, most easily by allowing the image to creep away from one hair while keeping the other just tangent to it, and stopping all movement at the instant the image leaves the first hair. If the paper screen be held in place by an improvised wire holder, this makes an easy, convenient, and precise method of obtaining tangency, for the observer is standing in a natural position and far enough from the screen so that his eyes can watch the whole area of the image without strain. The image is larger than that seen when looking directly at the sun and better definition is possible. By this means it is believed that observations can be made fully as closely as the vertical circle can be read.

2. Some reticles have special crosshairs arranged in the form of a square or rectangle symmetrical about the center of the telescope, the size of the figure being so designed that the image of the sun will extend beyond the edges very slightly. The sun is then centered at each observation, and the image on the screen must be maneuvered by the use of both slow-motion screws until it is centrally placed on the shadow of the hairs. This requires considerable dexterity, and on the average it is not believed that the observations so made are as precise as those made by the tangent method. At first thought it might seem that this device would save the four pointings of the tangent method, but on the other hand decreasing the number of pointings is not desirable, for the more pointings that are made the more probable will the errors of observation compensate and give better values for the vertical angle.

3. Either of the two means just explained may be used for direct vision through the telescope, by attaching a colored plane eyepiece or a colored prism eyepiece. Using either of these attachments requires the observer to be in a cramped and uneasy position, particularly when the sun is high. Also, there is usually a slight movement or haziness to the edge of the sun and the sharp definition of the image on the paper is lacking. In a high power telescope the image of the sun, viewed directly, covers nearly the entire field, and it is practically impossible to watch all four sides and receive instantaneous impressions, and even two sides are watched with difficulty. When the image is caught on a screen the observer

stands far enough away so that the whole figure is watched easily, and without eyestrain and the consequent decrease in accuracy of perception. It is believed that the tangent-image method will be found most satisfactory.

(c) The desirable number and sequence of pointings. The most simple observation would consist of one pointing at the sun, with a check back on the mark, giving two readings of the horizontal angle, one of the vertical angle and one attempt at estimating the direction of the sun. This is far from a well balanced observation, but in case of clouds it might be all that could be had. It could be used by correcting both the azimuth and the vertical angle for the semi-diameter of the sun, assuming the tangent-limb pointing to have been used. The semi-diameter varies but little throughout the year, being as follows:

January and December	16.25	min.
February and November	16.20	"
March and October	16.10	"
April and September	15.95	"
May and August	15.85	"
June and July	15.75	"

Having only one pointing, the vertical angle would be corrected by applying the full amount of the semi-diameter given above, and the azimuth angle would be corrected by applying this semi-diameter multiplied by the secant of the corrected altitude angle. This would reduce the observed values to the center of the sun, and computation might give results approximately correct, but not reliable.

The least number of pointings should be two, consisting of a direct and a reversed, or inverted, sight, placing the image of the sun in opposite quadrants, and checking back on the mark. Inversion largely compensates for errors of adjustment, while using diagonally opposite quadrants gives an average value which represents the center of the sun. But this is out of proportion in that there are two readings each of the horizontal and the vertical angles, altho the vertical angle can usually be read with nowhere near the certainty of the horizontal angle. An observation like this can usually be made in five minutes, and for this reason is convenient.

The next best arrangement consists of four pointings at the sun, two direct and two inverted, and each pair in diagonally opposite quadrants, the two quadrants used depending upon the direction of movement of the sun. One pointing may be made in each of the four quadrants if desired, but in two of them the movement is not as convenient for observation as the others and nothing is gained. In either case the direct pointings should be to diagonally opposite quadrants, and similarly with the inverted sights. This procedure gives two readings of horizontal angle and four readings for the vertical angle, and requires about eight minutes of time.

The Heavy Artillery School, A. E. F., makes use of the following procedure. The upper left quadrant is numbered 1, lower right is 2, upper right is 3 and lower left is 4. Sights are then taken as follows:

direct to the mark,
direct to quadrants 1 and 2,
reverse to quadrants 3 and 4,
reverse to quadrants 3 and 4,
direct to quadrants 1 and 2,
direct to quadrants 1 and 2,
reverse to quadrants 3 and 4,
reverse to the mark.

Each pair is then averaged, giving the center of the sun for that pair. These six mean pointings are then listed, checked for proportionality between successive readings, and finally averaged to obtain the final data for computation, after any readings showing poor proportionality have been discarded. The final average assumes that the average of the azimuth readings and the average of the time readings are coincident, that is, represent the same position of the sun. While this is not true the error is small if the total time of observation does not cover more than fifteen minutes. This method gives four measures of the horizontal angle to the mark, using both verniers, twelve readings of the vertical angle and twelve pointings at the sun, using the tangent image method.

These various methods illustrate the more frequently used schemes in solar observations, and the manner of making provision for the uncertainties. But perhaps it might be suggested that the more minute details are after all not as important as some of the more important unknowns which are liable to be overlooked. At best solars are approximate. Lt. Col. Birdseye of the A.E.F. School says that they are suitable when direction is required only within two minutes of arc, and the averages of all the A. M. and all the P. M. observations listed on Plate I show exactly this difference. The reason for a large part of this difference is that A. M. sights were over a water area and P. M. over a land area, with a consequent variation in the refraction correction. Without knowledge of the air conditions, tabular corrections had to be used though known to be in error. For this reason greatly increasing the number of pointings in any one observation is questionable. It would appear to be better to accept the azimuth of a line from solars only when a consistent average was obtained from a number of observations taken under varying conditions of time, weather, season, etc. The other, and perhaps the better, use of solar observations is to serve as a check in the course of work where it is desired to prevent the occurance of large errors in azimuth due to faulty instrument work, such as in running traverses from lines already oriented; or as a means of obtaining only approximate orientation until more precise determinations could be made.

SOLAR OBSERVATIONS—HOUR ANGLE METHOD

Theory.—In the general case of star or sun observations by altitude method, of which the preceeding Solar Altitude Method is one form, the three sides of the so-called "Astronomical Triangle" are either measured or obtained from tables, by means of which the angle at the observer's zenith is computed. This Hour Angle method is more or less of an emergency measure which furnishes one angle of this same triangle, so that it may be solved when one side, the altitude side, for some reason is not or cannot be measured. This angle is the so-called "hour angle," being the angle at the celestial pole between the observer's meridian and the great circle through the sun at the time of observation. Its value is a function of apparent time at the place of observation, that is, apparent local time. If the sun has passed or will pass the observer's meridian three hours before or after, respectively, the time of observation, its hour angle at the time of observation is 45 degrees—fifteen degrees for each hour of time. In this case the three hours are measured in local apparent solar time, obtained by changing standard time (mean solar time at the central meridian of the time belt in which the place of observation is located) to mean local time (standard time corrected for the difference in longitude of the place of observation and the central meridian of the time belt), then correcting to apparent local time by applying the equation of time between apparent and mean time as given for the date of observation by an ephemeris. Having computed this hour angle, and also having obtained from an ephemeris the declination of the sun at the time of observation, and knowing the latitude of the place of observation; two sides and the included angle of the "Astronomical Triangle" are known, from which the angle at the observer's zenith may be computed by the following two formulas:

$$\tan \tfrac{1}{2}(\text{Az.} - \text{p}) = \frac{\sin \tfrac{1}{2}(\text{lat.} + \text{decl.})}{\cos \tfrac{1}{2}(\text{lat.} - \text{decl.})} \times \tan \tfrac{1}{2}\,\text{HA}.$$

$$\tan \tfrac{1}{2}(\text{Az.} + \text{p}) = \frac{\cos \tfrac{1}{2}(\text{lat.} + \text{decl.})}{\sin \tfrac{1}{2}(\text{lat.} - \text{decl.})} \times \tan \tfrac{1}{2}\,\text{HA}.$$

Adding the values computed from each formula gives "Az.", which is the angle at the observer's zenith between true south and the sun at the time of observation. Combining this "Az." angle with the measured angle from mark to sun gives the angle between true north and the mark.

Practical Considerations.—This method provides for the minimum of field work, but substitutes considerable computation and the results are almost wholly dependent upon the accuracy of the time measurement used in computing the hour angle. Three seconds error in time result in one minute error in the computed direction. This alone practically eliminates it from the list of reliable field methods. The statement is sometimes made that it might be used in place of the solar altitude method in case the sky were partly overcast and only one pointing at the sun were possible. But even so the one pointing at the sun, corrected to the center of the sun by computation, if necessary, would give a far more reliable result by the altitude method than by the hour angle method. Apparently the only circumstance in which this latter method is unavoidable would be in case the vertical angle-measuring part of the instrument were missing or disabled, and sufficient time were not available for a Polaris observation or for an equal altitude determination; the latter being possible without a vertical circle, simply clamping the telescope in any convenient position.

As an interesting experiment five of the Solar, Altitude Method, observations were selected from the 28 determinations listed on Plate I, taking those which most nearly approached the accepted value of the azimuth of the line to which all the field work was referred. These five are listed under "Hour Angle", at the bottom of Plate I. These five observations when computed by the altitude method gave results varying from the accepted azimuth by the following amounts: 8″, 16″, 2″, 7″, and 61″. Using the identically same field data, but computing these five by the hour angle method, gave the widely varying results as shown on Plate I, the average error being 113″.

As a rule a knowledge of the time within a few seconds is out of the question, without making a separate observation for the determination of time. While the latter is not a serious matter, it appears to be a needless complication of the problem, when more simple and direct solutions are more easily available.

High Burst Ranging

By Lt. Colonel C. H. Birdseye, Coast Artillery

INTRODUCTION

A number of small pamphlets have been published describing different methods of High Burst Ranging. None of these completely covers the subject and in many publications some particular phase of the problem is treated in an entirely different manner. The object of this paper is to give a complete discussion of the problem of ranging by air bursts, explaining all the methods now in use and presenting several changes in methods which, to the writer, seem to be desirable.

None of the existing methods are satisfactory. In some cases the preparation for adjustment is simple but the instruments used in observing are poor and the methods of calculation are weak. In other cases very elaborate preparation for adjustment is required and the computations are intricate and require considerable time before the results can be given to the battery. It is true that the different methods have been devised for different types of artillery but it seems perfectly feasible to develop a single method with variations to meet the needs of different types of guns.

Accurate adjustment by air burst ranging has been thoroughly demonstrated by the French, British, and German Artillery. It may be employed to advantage under the following conditions:

(a) When the target is invisible from the observation stations and observation from aeroplane is for any reason impracticable.

(b) When other batteries are firing on the same target, making it difficult to distinguish the fall of the shells of the ranging battery.

(c) When it is desired to resume a previously adjusted fire under different atmospheric conditions.

(d) For calibration of guns or comparison of powder lots.

(e) In adjustment of fire on captive balloons, furnishing an ideal method of adjustment without alarming the target.

This method of ranging is of particular value to the Artillery since it permits:

(a) The adjustment of fire at night when the method works even better than by day.

(b) A reduction in the number of aeroplanes required for artillery observation.

(c) A wide range in choice of height of burst.

The disadvantages of the method are as follows:

(a) Not capable of adjustment of fire on a moving target.

(b) Useless when the atmosphere is very hazy, preventing visibility.

(c) Requires a highly trained personnel.

There are three distinct and different methods of adjustment by air bursts, each one having several variations, as follows:

1. By terrestrial observation sections.
   - (a) French S.R.O.T.,*—Ranging on the true trajectory.
   - (b) U. S. Flash Ranging Sections,—Ranging on the true trajectory.
   - (c) British Field Survey Co.,—Ranging on a point directly above the target (False Angle of Site Method).
2. By the battery personnel,—Tangent Reticule Method.
   - (a) Adjustment on target which has been registered on by previous fire.
   - (b) Adjustment on point on true trajectory.
   - (c) Adjustment on point directly over the target.
3. By special high burst ranging sections.
   - (a) French Sections Telemetriques pour Reglage par Coups Fusants Hauts, under the control of the Reserve Generale d'Artillerie.
   - (b) U. S. Provisional High Burst Ranging Sections.

The first two methods were designed for adjustment of fire by the Field Artillery and the third for heavy long range matériel. Each of these methods will be discussed in the order given above, with sufficient theory and examples to give a clear understanding of the details.

Ranging on the True Trajectory

The general principles of this method are as follows:

(a) The ranging section selects a fictitious point of adjustment on the true trajectory at suitable height above the target so that the bursts will be visible from the observation stations.

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* Sections de Renseignements par Observation Terrestre.

(b) The gun is fired with elevation and deflection required to hit the target but with time fuse set to bring the burst at the selected point of adjustment.

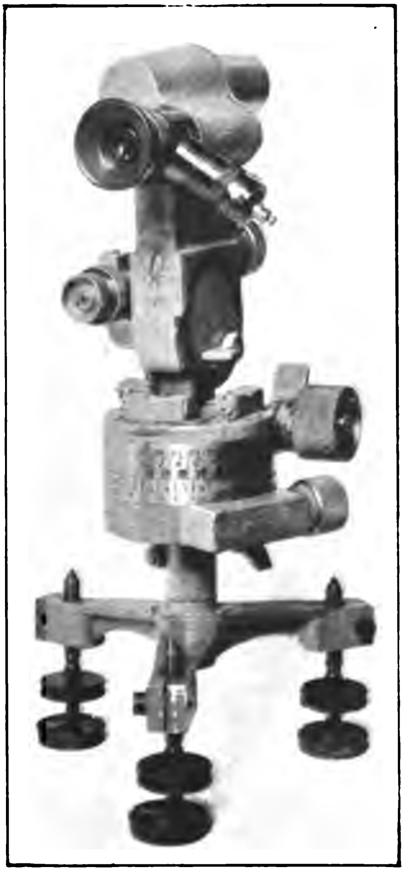


Plate I 2331

(c) Bursts are observed from the observation stations and the horizontal and vertical deviations from the point of adjustment are determined.

(d) The ranging section plots the position of each burst and determines the position of the mean point of burst of a series of shots. By means of trajectory charts an imaginary center of impact for the series is determined and the proper corrections in range and deflection to shift this center of impact to the target are given to the battery.

Observation of Bursts

At least three observation stations are used, so selected as to give favorable intersections on the point of burst. Observations may be made with any good type of observation instrument designed to read horizontal and vertical angles. It is preferable to use separate observers in the same station for horizontal and vertical angle measurement, three determinations of the horizontal position and two of the vertical position being sufficient.

The French S.R.O.T. uses a special type of instrument (see Plate I) similar to the Aiming Circle but with one barrel of a prismatic field glass for sighting device and a more stable base suitable for mounting on a permanent support or on a tripod. A sub-scale for reading deflections from the point of adjustment is placed in the focal plane of the instrument.

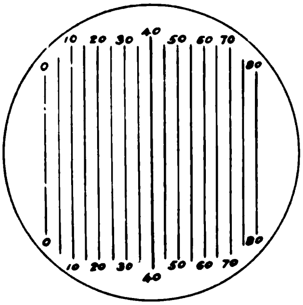


Fig. 1 2332

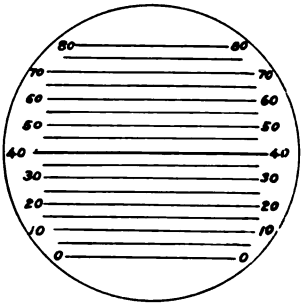


Fig. 2 2333

The instruments are made in pairs, one for horizontal and one for vertical angle measurement, the only difference being in the subscales. In the horizontal angle instrument the graduations on the subscale are vertical (see Fig. 1) and in the vertical angle instrument they are horizontal (see Fig. 2). The graduations are in 5 mil intervals covering a field of view of 80 mils with zero graduation at the left in the horizontal angle instrument and at the bottom in the vertical angle instrument. In each case the graduation 40 mils represents zero deviation from the reference plane. In other respects the instrument is exactly like the Model 1916 Aiming Circle.

The writer does not consider this instrument sufficiently accurate for high burst ranging and suggests the following modifications:

(a) A larger limb with horizontal angle graduations marked

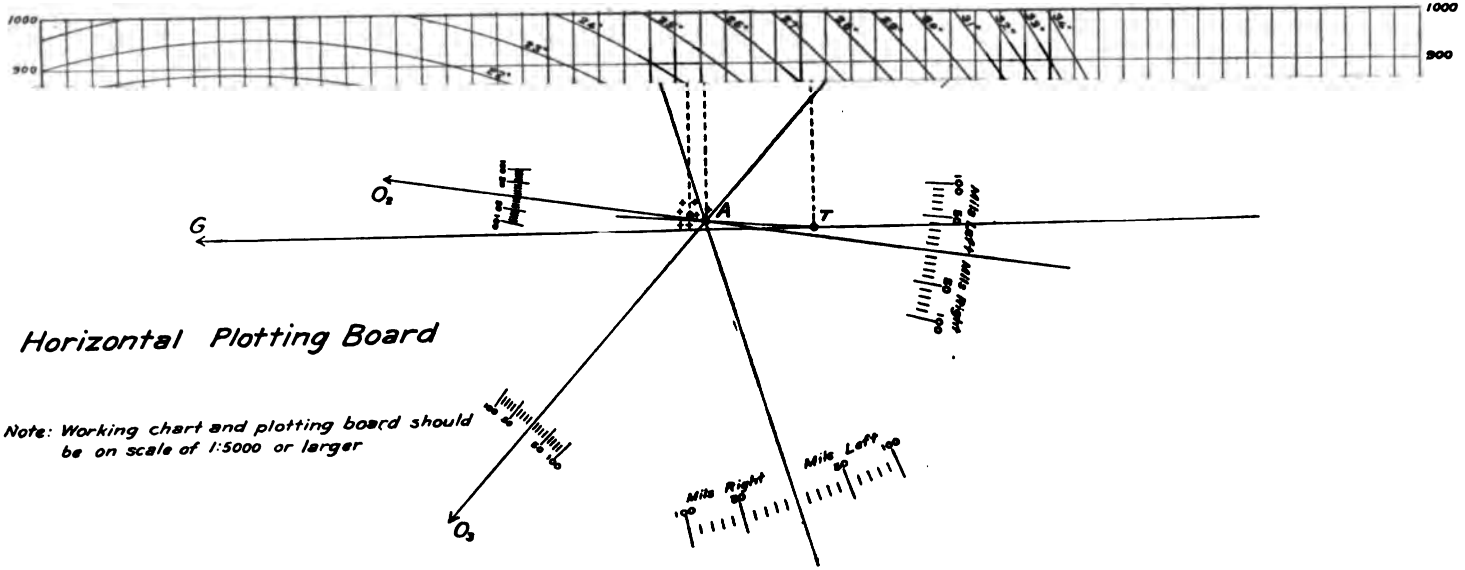
PLATE II

HIGH BURST RANGING CHART

75 mm Gun, High Explosive Shell, Normal Charge

Short 24/31 Time Fuse, Model 1915

Range Tables, Dec. 1917



Horizontal Plotting Board

Note: Working chart and plotting board should be on scale of 1:5000 or larger

in 10 mil intervals, subdivisions to be read by micrometer to 1/10 mil.

(b) Larger vertical arc with graduations to 10 mils and subdivisions to mils by micrometer or vernier.

(c) Longer level bubbles for vertical arc and two cross bubbles for horizontal plate. All bubble tubes should be adjustable.

(d) Larger telescope with field of view of at least 100 mils, both horizontal and vertical graduations to be placed on the same subscale to permit interchange of instruments or combination use. It is believed that such modifications would produce an observation instrument suitable for all kinds of terrestrial observation with mobile armament.

The Y-azimuth and angle of site from each observation station to point of adjustment (expected point of burst) is determined by the central station and given to the proper observers. The instruments are then directed on this imaginary point and deflections read on the subscales.

Plotting Observations

Any type of plotting board may be used in the central station provided the scale is sufficiently large. In order to obtain good results the scale should be at least 1/5000 and preferably 1/2000. A mechanical board is not required, the horizontal and vertical positions of bursts generally being plotted on the ranging chart as explained later.

Trajectory Charts

Two charts are used—Ranging Chart and Time of Flight—Fuse Setting Chart. The Ranging Chart (Plate II) is made up of a series of descending branches of trajectories projected on the vertical plane through the gun-target line. These trajectories are drawn for each degree of quadrant elevation. Abscissae are arguments of range plotted on a scale of 1/10,000. Ordinates are arguments of altitude above and below the initial plane, plotted on a scale of 1/5000. It is believed that better results would be obtained if the range and altitude scales were the same and at least as large as 1/5000. The chart shown in Plate II has been reduced and represents trajectories for the 75 mm. gun, high explosive shell, normal charge, 34/31 short time fuze, and initial veloctiy of 550 meters per second.

The ranging sections are supplied with ranging charts for each type of gun, charge, and fuze for which it is probable that adjustment by this method will be required. These charts may be made in two ways.

First Method.

The parabola of the lower part of the descending branch of the trajectory is replaced by the arc of a circle whose tangent coincides with the tangent to the trajectory at the point of fall. This assumption is sufficiently accurate for use with this method of adjustment. The radius of the circle is computed by the formula:

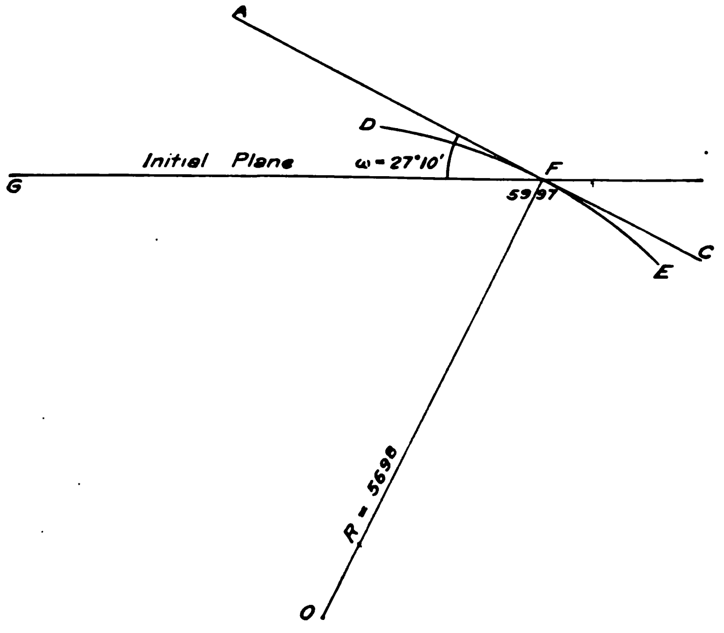


Fig. 3

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$$R = \frac{(Vr)^2}{g \cos \omega}$$ in which Vr = tangential remaining velocity

g = 9.81 meters per sec.

ω = angle of fall.

The projections of these trajectories are computed from range table data for each degree of quadrant elevation between the limits desired. Take for example the trajectory for quadrant elevation 17° in Plate II. (Extracts from the range tables for the 75 mm. gun are given at the end of this discussion.) The corresponding range is 5997 meters, the angle of fall is 27° 10′

and the tangential remaining velocity is 223 meters per second. At the point representing range 5997 (see Fig. 3), the line AC is drawn at an angle of 27° 10′ from the line GF, representing the initial plane. The line FO is drawn at right angles to AC.

$$\text{Radius} = \frac{(223)^2}{9.81 \cos 27^\circ 10'} = 5698.$$

The arc DE is drawn with center at 0, 5698 meters from F.

Second Method

For each trajectory it is assumed that near the point of fall the tangential remaining velocity is constant and that the distance traveled by the projectile during a few seconds above or below the point of fall is the tangential remaining velocity times the number of seconds. The tangent AC is drawn as in the first method. The points $t-_1$ and $t+_1$ (see Fig. 4) are plotted on this tangent at distance from F equal to the tangential remaining velocity. From these points perpendiculars are dropped 4.9 meters to scale, which is the distance travelled by a falling body in the first second and found by the formula:

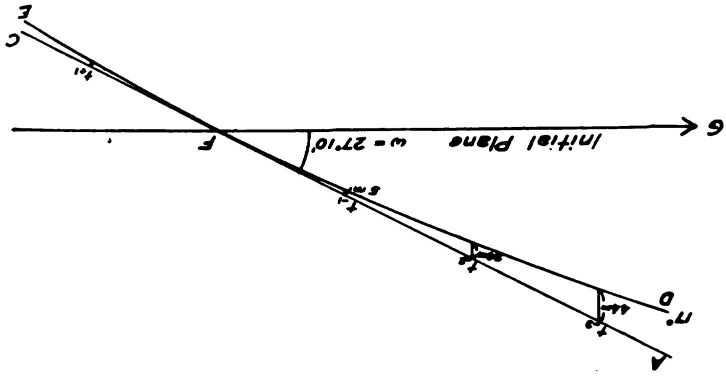

Fig. 4 2335

$S = \frac{1}{2}gt^2$ in which S = distance dropped.
g = 9.81 m. per sec.
t = time interval.

The process is repeated, plotting a sufficient number of positions to definitely locate the curve representing the trajectory between the desired limits (about 10 sec. above and 5 sec. below the point of fall.)

Neither of these methods is exact nor will either hold even approximately true for a long distance from the point of fall. In the first method, the radii of the arcs will be so long that construction will be difficult, consequently the second method will be found more practicable. The trajectories plotted by either method will represent normal conditions. An appreciable longitudinal wind component will change the angle of fall and consequently change the projection of the trajectory. For convenience the trajectories are drawn to fit normal conditions and any particular one can be modified to fit different conditions at time of use.

The lower part of the ranging chart is used in plotting the horizontal position of the bursts and will be explained later.

Time of Flight—Fuze Setting Chart

This chart (see Plate III) is constructed for the use of the battery commander in determining the fuze setting for time fire. The projections of the trajectories are constructed in the same manner as in the ranging chart except that they are drawn in a sheaf converging at a point representing the point of fall. On each trajectory is plotted the positions of the projectile at half second intervals above and below the initial plane. Curves are drawn joining these positions and used to interpolate intervals of time of flight on other trajectories.

The chart contains a conversion scale giving the fuze setting with arguments of quadrant elevation and of time of flight, and also a correction scale giving range, elevation, and deflection corrections for changing from time fire to percussion fire.

Use of Fuse Setting Chart

The battery commander prepares the initial firing data for fire on the target with fuze that will be used in fire for effect, taking into account the corrections for drift and meteorological conditions. If the fire for effect is to be with percussion fuze having ballistic properties different from those of the time fuze, he then determines the elevation and deflection correction (using with opposite signs the values given in the correction scale) for fire on target with time fuze. With the quadrant elevation thus obtained and the height of the expected point of burst with reference to the initial plane as arguments, he enters the time of flight chart and determines the correction to time of flight to bring the bursts at the point of adjustment. From the conversion scale (or from the range table) he deter-

mines the time of flight to point of fall and subtracts or adds the correction to time of flight according as the point of adjustment is above or below the initial plane. From the same conversion scale he determines the fuze setting for the corrected time of flight which will bring the burst at the point of adjustment.*

Example

Given map range of 6000 meters, target 35 meters below the level of the gun, no wind, and atmospheric conditions normal. Fire for effect with 75 mm. gun, high explosive shell, normal charge, and long IA 24/31 percussion fuze. Fire for adjustment with the same shell and charge but with short 24/31 time fuze, Model 1915.† Height of burst 200 meters above the horizontal plane through the target.

From the Range Table Vb_1 (see page 432) the quadrant elevation for zero site is found to be 19° 21′ and drift 16 mils right. The site is -6 mils $= -20'$ and the corrected quadrant elevation is 19° 01′. From the range correction scale the correction in elevation for change from percussion to time fire at 6000 meters range is found to be $-2°$ 20′ and deflection correction to be 1.3 mils left. The corrected quadrant elevation for time fuze is 16° 41′ and corrected deflection from plane of fire is 15 mils right which agrees with the values found by use of Range Table Vb.

The conversion scale for fuze setting gives time of flight for quadrant elevation of 16° 41′ equals $21^s.5$. The height of burst above the initial plane is 165 meters and the correction to time of flight to bring the bursts at the point of adjustment is $-1^s.7$. The corrected time of flight is $19^s.8$ and the corrected fuze setting is 21.

Use of Ranging Chart

(See Plate II). The plotter in the central station of the ranging section plots the target at proper range and altitude and draws the trajectory through the target by interpolation between the trajectory curves. If there is an appreciable longitudinal wind component, the angle of fall will be slightly different from that used in constructing the chart and the interpolated trajectory through the target should be modified accordingly. The point of adjustment is then plotted at the proper altitude on this trajectory. The horizontal projection of the battery-target line is drawn on the lower part of the chart, parallel to the line representing the initial plane in the vertical projection. The position of the target is plotted on the horizontal projection and the drift curve, modified for lateral wind component, is plotted through the point representing the horizontal position of the target. The horizontal position of the point of adjustment is then plotted on this drift curve.

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* The chart might well be constructed with curves giving correction to fuze setting rather than correction to time of flight, thus eliminating the conversion scale.

† The long fuze is used in this example merely to illustrate the use of the correction scale on Plate III. Ordinarily one of the short percussion fuzes (see page 432) having the same ballistic properties as the short time fuze, would be used in fire for effect.

Y-azimuths and distances from the several observation stations to the point of adjustment are determined graphically (or computed) and lines are drawn through the horizontal position of the point of adjustment at the proper angles from the battery-target line.* Deflection arcs, graduated in the same intervals as the subscales of the observation instruments, are placed on these lines by means of a parallax protractor.

With the vertical observation instrument directed on the point of adjustment, a plane determined by the line of collimation and the horizontal cross wire of the instrument will cut the vertical plane through the battery-target line in a line through the point of adjustment. By elevating or depressing the instrument and passing a similar plane for each setting, a series of lines will be formed above and below the point of adjustment. The intersections will be right lines if the instrument is not turned in azimuth.

These intersections may be determined by the principles of descriptive geometry or by computation. For example, in Plate II, the line O_1A makes an angle in the horizontal plane from the line GT of 73° 25′. The distance O_1A is 3328 meters. The altitude of O_1 above the initial plane is 80 meters and the altitude of the point A is 165 meters above the same plane. The angle of site from O_1 to A is +25.5. mils.

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* If the scale of the chart is 1/5000 or larger, sufficient accuracy will be obtained by plotting on a transparent grid to the same scale, the positions of the observation stations and target and the direction of the battery-target line. The grid can then be superimposed on the chart and lines drawn through the point of adjustment in the direction of the several observation stations. The Y-azimuths and distances from the observation stations to the point of adjustment can be measured graphically with sufficient accuracy for use of the observers.

On the same transparent grid, used for determination of directions and distances from observation stations to point of adjustment, construct the line O_1N perpendicular to the line O_1A. (See Fig. 5). The horizontal axis of the instrument at O_1 (or the hinge of the planes of sight from O_1) intersects the vertical plane through the battery-target line at a point the horizontal projection of which is N. The horizontal projection of the intersection of the plane of sight from O_1 to A with the vertical plane through the battery-target line is represented by the line NM. The grid is then superimposed over the vertical projection of the trajectories with the point M over the point representing the point of adjustment and the point N at an altitude of 80 meters above the initial plane.

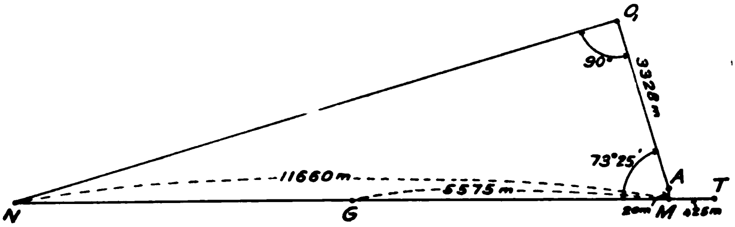

Fig. 5.

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From the point N are drawn the lines representing the intersections of the different planes of sight with the vertical plane through the battery-target line. The spacing of the lines along the vertical through the point of adjustment is computed by the mil relation using the horizont aldistance O_1M (1 mil = 3.35 meters). If it is not convenient to make the geometric construction, the distance NM may be computed by the relation:

$$NM = O_1M \sec 73^\circ 25' = 11{,}660 \text{ m}$$

in which, for all practical purposes, the displacement of A from M, due to drift and wind, may be ignored and the distance O_1A may be used for O_1M.

If the observation station is at right angles to the battery-target line, the point N will fall at infinite distance from M and the lines representing the intersections of the planes of sight with the vertical plane through the battery-target line will be parallel to the line representing the horizontal plane through the observation station. If the observation station is on the battery-target line, the points O_1 and N are identical and the distance NM will equal O_1M. In actual practice it is not necessary to make a rigid construction or computation provided the observation station is at considerable distance from the point of adjustment. Inspection of the horizontal and vertical projections will determine the approximate inclination of the lines representing the vertical intervals.

The chart is now ready for use and, if the proper facilities have been available, its preparation should not have required more than 15 minutes.

The battery then fires one or more shots to assure bursts in the field of view of the instruments. In case it is necessary to change the height of burst, the fuze setting and not the elevation will be altered. A series of at least 8 shots is then fired, by the ranging gun or in battery salvos, without changing elevation, deflection or fuze setting. The position of each burst is plotted by the ranging section from the results of at least three horizontal and two vertical observations. The horizontal position of the mean point of burst is plotted on the lower part of the ranging chart and projected vertically upward to the line representing the mean vertical position. Through this point is drawn the remaining portion of the trajectory to intersect the horizontal plane through the target at a theoretical center of impact. The error in range is scaled from the vertical projection (distance from theoretical point of impact to target*) and the error in deflection is scaled from the horizontal projection (distance from mean point of burst to drift curve). These deviations are reported to the battery.

The battery then combines the corrections given by the ranging section with the corrections necessary for changing from time to percussion fire and proceeds with fire for effect.

RANGING ON A POINT DIRECTLY ABOVE THE TARGET

This method is sometimes called the *False Angle of Site Method* of adjustment. The general principles are as follows:

(a) The ranging section determines the height of burst above the target so that the bursts will be visible from the observation stations.

(b) The gun is fired with quadrant elevation, deflection, and fuze setting required to bring the bursts at this point of adjustment.

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* If there is considerable difference of altitude between the battery and target, the battery commander will require range errors measured in the initial plane.

(c) Bursts are observed from the observation stations and horizontal and vertical deviations from the point of adjustment are determined.

(d) The ranging section plots the position of each burst and determines the position of the mean point of burst of the series of shots with reference to the point of adjustment. These deviations are given to the battery. The battery then computes the data necessary to change from time to percussion fire and to shift the mean point of burst on the target.

The same procedure in observation of bursts is followed and the same type of instrument is used as described in the method of ranging on the true trajectory.

Plotting Observations

The horizontal positions of the bursts are plotted on the same plotting board used by the section for ordinary terrestrial observation, provided the scale is sufficiently large. If it is desired to prepare a special plotting chart, the same procedure may be followed as in preparation of the lower part of the ranging chart used in ranging on the true trajectory, except that the lines representing the directions of the observation stations are drawn through the point representing the target. No vertical projection of the trajectory is necessary.

Procedure in Adjustment

The battery gives to the ranging section the following data:

(a) Co-ordinates of ranging gun and target.
(b) Map range and Y-azimuth from ranging gun to target.
(c) Altitude of ranging gun and target.
(d) Angle of site from ranging gun to target.

The ranging section computes the height of burst above the target necessary to assure bursts in the field of view of the instruments. The Y-azimuth from each observation station to target and the angle of site from each station to point of adjustment is determined graphically (or computed) and the data given to the proper stations. The observation instruments are then directed on the point of adjustment. The angle of site from ranging gun to point of adjustment is given to the battery.

The battery commander may prepare the initial firing data in two ways, the first of which is preferred;

First Method.

The firing data is computed for time fire on the point of adjustment, exactly as though the target were at that point. (See Fig. 6)

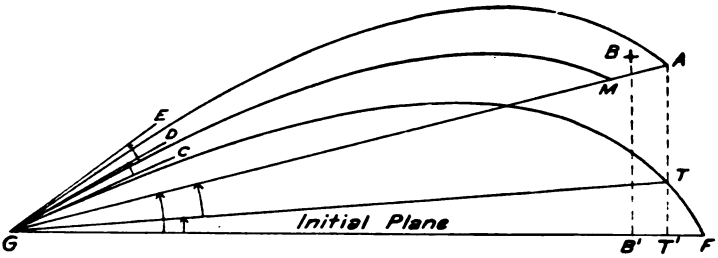

Fig 6

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False Angle of Site

Angle T'GT = site to target.
Angle T'GA = false site to point of adjustment.
Angle TGA = CGD = difference of site.
Angle DGE = complementary site correction.

The fuze setting is determined from the proper Time of Flight—Fuze Setting Chart as described in the method of ranging on the true trajectory.

The battery gives to the ranging section the time of flight to the burst. One or more preliminary shots are fired to assure the bursts being in the field of view of the instruments. If it is necessary to change the height of burst, only the fuze setting is altered. A series of at least eight shots is then fired without changing quadrant elevation, deflection, or fuze setting.

After deviations from the point of adjustment have been reported, the battery commander computes the data necessary to shift the fire from the mean point of burst to the target and applies the corrections for change from time to percussion fire as determined from the correction scale on the Fuze Setting Chart.

Second Method

The initial firing data is computed for fire on the target with fuze that will be used in fire for effect. The data is then corrected for difference of site between the target and point of adjustment and for change from percussion to time fire. The fuze setting required to bring the burst at the proper altitude is determined from the Fuze Setting Chart. The bursts may then be expected approximately on the line of site to the point of adjustment but short of that point (at M in Fig. 6) for the reason that no complementary site correction has been made other than that for site to the target. After deviations from the point of adjustment have been reported, the battery commander allows for the expected deviation in range due to lack of complementary site corrections and applies the remaining correction for range deviation, the corrections for deflection, difference of site and for change from time to percussion fuze.

Fire for effect is then carried out.

It is evident that the principal difference between ranging on the true trajectory and ranging on a point directly above the target is that the observation section performs most of the work in the first, and the battery personnel in the second method. The division of work is a question of policy but the writer does not believe that the personnel of a terrestrial observation service should be called upon to make any ballistic calculations. If the observations are made by artillery personnel, this objection is removed.

It is believed that a modification of the method of ranging on a point above the target, in which the point of adjustment is selected in *any direction* at approximately the range to the target, offers possibilities of development superior to any other method of high burst ranging. The process of directing the observation instruments on any imaginary point is no more difficult than on a point directly over a concealed target. The computation of firing data to bring the bursts at this imaginary point and then to shift the fire to the actual target is exactly the same as though the fire were adjusted on a visible auxiliary target located at the imaginary point. This is a problem with which every battery commander in mobile artillery is familiar and which he often fires. One great advantage would be in failure to alarm the target. This is often very important.

EXTRACTS FROM FIRING TABLES
75 mm. GUN, MODEL 1897

TABLES Vb, VIb,

H. E. SHELL, SHORT FUSE

Short fuse. ($V_0 = 550$ m.)	24/31 percussion fuse, Model 1899 24/31 percussion fuse, Model 1899-08. I fuse, Model 1914. 24/31 time fuse, Model 1915. 24/31 combination fuse, Model 1916. 24/31 Ry fuse, Model 1917.

TABLES Vb_1, VIb_1,

H. E. SHELL, LONG FUSE

Long fuse. ($V_0 = 542$ m.)	IA 24/31 percussion fuse, Model 1915. IAL percussion fuse, Model 1916, with or without plate.

TABLE Vb, continued H. E. SHELL, SHORT FUSE $V_0 = 550$m.					TABLE Vb_1, continued H. E. SHELL, LONG FUSE $V_0 = 542$m.				
Range in meters	Elevation		Range setting	Drift in mils	Range in meters	Elevation		Range setting	Drift in mils
	Degrees and minutes	Mils				Degrees and minutes	Mils		
5500	14° 26′	257	Laying by quadrant	12	**5500**	15° 57′	284	Laying by quadrant	13
5600	14° 56′	266		12	**5600**	16° 36′	295		13
5700	15° 27′	275		13	**5700**	17° 16′	307		14
5800	15° 58′	284		13	**5800**	17° 56′	319		14
5900	16° 29′	293		14	**5900**	18° 38′	331		15
6000	17° 1′	302		15	**6000**	19° 21′	344		16
6100	17° 34′	312		16	**6100**	20° 5′	357		17
6200	18° 8′	322		16	**6200**	20° 52′	371		17
6300	18° 43′	333		17	**6300**	21° 42′	386		18
6400	19° 19′	343		17	**6400**	22° 35′	402		19

TABLE VI_b

H. E. SHELL SHORT FUSE $V_0 = 550^m$

RANGE in Meters	BRACKET	ANGLE OF FALL	TANGENT OF ANGLE OF FALL	TIME OF FLIGHT	MAXIMUM ORDINATE	TANGENTIAL REMAINING VELOCITY	DISPLACEMENT of POINT OF FALL: in range for 1 mil of site	in range, for 5' of elevation	in height, for 5' of elevation	in direction, for 1 mil of deflection	PROBABLE ERROR: in range	in direction	SETTING OF 24/31 FUSE FOR O BURST	Os 1 IN FUSE setting displaces burst by: height in meters	height in mils	range in meters
	° '	° '		sec.	m.	m.	m.	m.	m.	m.	m.	m.				
5000	27	19 26	0.352	16.7	375	236	12.8	19.0	6.7	4.9	17.9	2.7	17.3	7.8	1.6	20
5500	35	23 7	0.427	19.1	482	229	11.9	16.8	7.2	5.4	19.8	3.2	20.1	9.0	1.6	19
6000	43	27 17	0.516	21.8	628	223	9.3	14.6	7.6	5.9	22.0	3.8	23	10.2	1.7	18
6500	55	31 53	0.622	24.8	811	220	8.4	12.5	7.8	6.4	24.6	4.4	.....	11.8	1.7	17
7000	1 13	37 3	0.755	28.2	1041	218	7.1	10.5	7.9	6.9	28.0	5.1	.....	13.5	1.9	16

TABLE VI_{b1}

H. E. SHELL LONG FUSE $V_0 = 542^m$

RANGE IN METERS	BRACKET	ANGLE OF FALL	TANGENT OF ANGLE OF FALL.	TIME OF FLIGHT.	MAXIMUM ORDINATE.	TANGENTIAL REMAINING VELOCITY.	DISPLACEMENT of POINT OF FALL: in range, for 1 mil of site	in range, for 5' of elevation.	in height, for 5' of elevation.	in direction, for 1 mil of deflection.	PROBABLE ERROR: in range.	in direction.
	° '	° '		sec.	m.	m.	m.	m.	m.	m.	m.	m.
5000	53	20 47	0.380	17.2	391	229	10.6	15.7	6.0	4.9	28.7	2.7
5500	1 18	24 37	0.479	20.2	538	219	8.9	13.2	6.3	5.4	33.6	3.2
6000	1 42	31 22	0.610	23.5	725	211	7.4	10.9	6.6	5.9	39.0	3.8
6500	2 42	37 52	0.777	27.4	986	207	6.0	8.9	6.9	6.4	45.0	4.4
7000	4 4	45 55	1.032	32.5	1360	209	4.7	7.0	7.2	6.9	51.5	5.1

(To be continued)

EDITORIAL REVIEWS

"The Queen of Battles"

It was a beautiful day in June last year in the Marne valley. A French Division was giving a demonstration of the attack of a strong point. All arms were there, Infantry, Artillery, Tanks, Machine Guns, Engineers, and airplanes. The French officer who explained the problem and described its progress had great difficulty in making himself clear in English. At times he would say: "She is checked," or "She advances," and his hearers wondered for a time who "She" was. "She" seemed to be the heart and soul of the whole problem. He spoke of her so anxiously, so reverently and with such assurance that eventually his hearers understood.

"She" was the thin Infantry line of attack. When "She" was checked the planes, without delay, must find out why and where, and the Artillery and Tanks must throw all their strength against the thing that checked her.

This simple and complete acceptance of their part by the auxiliaries was the best lesson of the day's work. There was no question, no hesitancy, no doubt of their relation to the Infantry. It was not simply doctrine; it was a rule of action; they knew it; it governed all their movement and their thoughts. The Infantry accepted it as their due. To the division engaged in the demonstration all this was obvious, but not so to all the American officers who were watching, perhaps for the first time, a combined action of all arms.

Doubtless all of them had been taught that all other arms exist as aids to the Infantry, but they were not imbued with this doctrine or prepared to shape all their actions and lay down their lives in accord with it. Many Artillerymen still announce that they conquer in order that the Infantry may occupy. It was not long ago that we were being told that gas or tanks or airplanes or ships, or even food, would win the war.

This last war and every other war of any magnitude was not won until the Infantry, assisted by all of its many aids, had imposed its will on the enemy's infantry. Let us not forget this. Let us never be led astray by false prophets or men who, immersed in the study of their own arm, forget this fundamental fact of war. If you belong to an auxiliary arm you must subordinate your training, your organization, and your thoughts to the needs of the Infantry. Only by such a policy can you hope to be of adequate use to the arm for whom you exist.

This proper relation of all arms to the Infantry goes much farther in its application than to Divisions, Corps, and the Army. It extends throughout all our means and organization for carrying on war. We have said that the decision is only reached by Infantry action. This is true in any case. A Naval engagement simply decides upon whose soil the final battle will be fought. A harbor defense action will in the end simply determine whether the *Infantry* of the enemy will land conveniently in a sheltered port at his pleasure, or be forced to come ashore on the beach to the great advantage of our *Infantry*. If we gain control of the sea we will invade the enemy to secure a decision with our *Infantry*, and *all* arms, as aids, will accompany it. If we lose control of the sea we will be invaded, and all arms, as aids to the Infantry, will take part in the struggle with the invading force. In either event there is no arm, no soldier, no camp follower who does not owe his allegiance and the subordination of his spirit to the arm for whose aid he is created.

Heretofore the elements of our defense have been scattered in times of peace in small detachments from Portland, Mane, to Tientsin, China. They have been controlled through Administrative Departments which have little or no relation to our problems of defense. Their peacetime organization and training should be such as will make real their very simple and direct relation to the Infantry—just as war makes it real. In this lies the true reason for the divisional and corps organization to be maintained in peace as well as in war. We all recognize the great necessity for "Teamwork" in war. We have taught it in our schools, we have preached it in our regulations—yet we have never recognized it in our peace organization, and we can not have it except as a result of such recognition.

With all the elements of the national defense organized in army corps and trained as aids and not as little independent units, their true relations to the whole would be a matter of discipline and training, and not a matter of doctrine to be appreciated only after the emergency comes. Not the least of the many advantages of such organization would be the brotherhood and the understanding of each other's problems that would surely come from daily contact in common service. In no other way can the auxiliary arms hope to appreciate the needs of the Infantry and train to meet them. In no other way can the Infantry realize the power or appreciate the limitations of its aids. This union will result in more than common doctrine; it will result in a common understanding, a common purpose and better yet, a common action—which is teamwork.

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Over the Horizon

A distinguished general officer now serving in Germany, in commenting recently upon the future course of events for the army, made the observation that perhaps the best thing that could happen to the army to enable it to be ready for another war would be immediately to get rid of everybody who has served in the great war which has just closed. This observation was casual and half-serious, but the idea elaborated is worthy of sober thought. Even now every officer is reading the lessons of this war in the light of his own experience. Invariably the conclusions are stoutly maintained, although even brigade and division commanders were limited in their personal experience to the observation of a few battles, a part of the theatre of operations and a limited series of problems in the combined use of the tactical weapons at their disposal. So the most opposite views of every detail of doctrine are being vouched for by somebody. One concludes that trench mortars will have no place in any future operations, while another is sure that the trench mortar properly designed is the ideal accompanying gun for infantry. It is maintained that all artillery should cast aside the preparation of fire from quadrillage maps, while it is also insisted that the first step in preparing for any future war should be the careful survey of every conceivable theatre of operations, and the compilation of a complete series of maps with quadrillage for all these areas. There are those who see in the newly designed caterpillar gun mounts the answer to all tractor artillery difficulties, while there are others who are equally convinced that the idea of combining motor unit and gun unit on one mount is fatally erroneous, and so it goes through every detail. Divergences of opinion exist which sweep the gamut from the trivial to the profound.

This does not mean that there are no generally acknowledged principles of tactics or technique still subscribed to, nor does it mean that there are no valid principles to be deduced from experiences which now seem to afford only ammunition for controversy. What it does mean is this, that an impartial analysis of all the experience available on any given subject is more likely to be forthcoming from a well trained mind which is nevertheless innocent of participation in any of the experience under study. This fact is a natural and proper outcome of human egotism. Any man who has successfully accomplished a result, inherently values his own judgement in the business in hand.

Egotism is not the only justification for the general's idea of "Oslerizing" us all. Inertia can easily prove another. There are some officers in the service who can remember with respect and veneration certain veterans of our old Indian campaigns whose conceptions of tactics, organization, and training never progressed beyond the ideas that had justified themselves as sufficient in the days of frontier Indian warfare. These splendid old soldiers had given noble service in a class of operations which were unique in their demands upon endurance and heroism. Yet no subsequent war has been fought out on the lines of the experience of the Indian campaigns and some of these officers in later days failed to command the respect which their years would inspire, because their minds had remained inert to the inevitable change which is the law of progress in every field of human effort. So now in the immediate retrospect of the mightiest war in history we cannot conclude that a future war will not be more staggering in the immensity and novelty of its operations.

The Coast Artilleryman, alike with the rest of the army, the nation, and the whole world, is on the threshold of reorganization—another generation—a new and mighty era. After the jockeying in the field which is inevitable in this period of reaction and peace negotiations, the whole world and everything in it is going to get straightened out, headed down the course, presently under the wire and the bell will ring for the new and as yet the greatest handicap. The new Coast Artillery will have a bigger job. The future field of the Coast Artillery will include Coast Defense in its broadest aspects, on a comprehensive scale that has not before been conceived, and in addition will include the solution of the problems concerning the land employment of heavy high-powered guns—in itself a field of tremendous opportunity whose boundaries have not even been traced in formal decision. If the Coast Artilleryman lives up to his new job and meets his opportunity it will be because he is big enough to realize that *egotism* and *inertia* are clinging garments which he must strip off if he is to be unhindered in the race. He must be frank enough to acknowledge that no matter how considerable was his achievement in the past war, it was not nearly so great as the effort he or someone else will have to make before and during the next war. This does not mean that he should forget everything he has seen and learned in this war, but merely that he must boost himself into the stature to look over and not look up to his past performance.

It has been said suggestively that in the next war the Coast Artillery will engage every naval target *over the horizon* or not at all; that if our batteries do not successfully engage their moving targets before those targets can be seen, the chance will be lost, and the batteries themselves will be silenced. This looks like a large order, and particularly to the Coast Artilleryman who can perceive the technical difficulties involved in firing at such extreme ranges with their consequently great dispersion against targets which cannot be tracked by any means of observation yet available, and with a problem of adjustment and observation of fire for which present means are inadequate. But this problem is undoubtedly only typical of the revolution in every problem of Coast Artillery technique which must be faced.

As we look out now to the horizon of our experiences and ideas, we may safely conclude that most of the ideas we are to engage as targets in our future work are over that horizon. Nevertheless, to successfully engage those ideas, we must aim correctly. When in the future we fire at moving vessels over the horizon, we will have made available the means of tracking them. Just now our task is even harder, for we have not yet the means at hand to spot and track the roving ideas which, somewhere over the horizon, are to be the targets of our future work.

In this particular problem however we are at an advantage, for we can increase our observation and press back the horizon of our experience by increasing the stature of our purpose—with a glass fitted with a new imagination and concentration, sweep a broader horizon which will reveal to us the problems we must meet.

As we pick up these ideas one by one they must be assigned immediately, and with the same solidarity of purpose in the officers of the Corps that has marked the teamwork of our plotting details. Then we can engage each successfully before we are overwhelmed by others, for therein is the fascination and the reward of this whole game—no matter how big the problem which confronts us, we may always be sure it is not the last, but there is another and bigger one just *over the horizon.*

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By Way of Suggestion

In the preliminary consideration of the conditions to govern the Prize Essay Contest for 1919, it was intended to present a list of subjects from which the essayist would choose. Finally it was decided to throw the field wide open so as to allow the greatest latitude in choice of subjects as well as in presentation of ideas. In the meantime, requests had been sent to the headquarters of the Coast Artillery Districts and Coast Defenses for the suggestions of different officers as to timely and worth while subjects for treatment in the Prize Essay Contest. A considerable response was made to these requests, a response which is much appreciated. The list of subjects suggested is assembled below, for two purposes, first, to present in virtual epitome the trend of thought on Coast Artillery problems, and second, by way of suggestion to Coast Artillery officers who are willing to be collaborators in the usefulness of the JOURNAL. From this list there must be at least one subject concerning which you, the thoughtful Coast Artilleryman, have distinctive experience or burning conviction which you may share with the rest of the Corps, either in the form of a crisp note, a more extended article, or an Essay in the competition for 1919.

Coast Defenses of New Bedford:
  Mobile Armament for Coast Defenses.
  Reconstruction.
  Units of Measure for Coast and Heavy Artillery.
  Relation of the Coast Artillery Corps to Other Arms.
Coast Defenses of Southern New York:
  The Re-Arming of Our Sea Coasts.
  System of Fire Control for Mobile Armament.
  The Organization Best Suited to Modern Artillery (Requirements).
  The Function of Railway Artillery in the Solution of our Coast Defense Problem.
Middle Atlantic Coast Artillery District:
  Training of Heavy Artillery for General Defense of the Coast Line, i. e., for Coast Defense Proper.
  Training of Anti-Aircraft Artillery.
  Observation of Long Range Fire Over Water and Corrections Therefrom.
  Anti-Aircraft Defense of the United States.
  Possibilities of Mobile Artillery for Coast Defense Purposes.
  Fire Control from Aircraft.
  How to Advertise the Coast Artillery.
  The Future of the Coast Artillery.
  A Type of Anti-Aircraft Defense of Large Cities.
Coast Defenses of the Delaware:
  Re-Organization of the Coast Artillery, Combining Railroad and Motorized Heavy Artillery with the Emplaced Artillery.
  Modernizing the Armament and Fire Control Systems of Our Coast Defenses.
  Promotion by Selection, and Its Effect on the Morale and Efficiency of the Commissioned Personnel of the Coast Artillery.
  Developments in Submarine Mining.
  Subaqueous Defenses of Harbors.
  Mobile Mounts for Trench Artillery.
  Front Line Heavy Artillery.
Coast Defenses of Portland:
  Railroad Artillery in Coast Defense.

Coast Defenses of Narragansett Bay:
  Motorized Artillery.
  Anti-Aircraft Artillery.
  Possibilities in Aircraft Artillery.
  Possibilities in Aircraft Artillery.
  Railroad Artillery in the Field.
  Railroad Artillery in Defense of Coasts.
  Railroad Artillery in Harbor Defense.

Coast Defenses of Galveston:
  The 8-inch Howitzer as a Mobile Unit of Heavy Motorized Artillery.
  Qualifications of an Efficient Battery Commander.
  The Importance of Up-keep of Transportation at All Times in Heavy Motorized Artillery.

The Tactical Uses Made of the 155 mm. Grande Portee Filloux Gun by the American Army Artillery in France.
The Relative Values of Heavy Motorized Artillery and Rwaylia Artillery Mounts for Our Coast Defenses.
Guns on Railway Mounts for Coast Defense.
Gas Shells for Coast Artillery.
The Employment of Coast Artillery Method of Fire Control by The Heavy Artillery of the American Expeditionary Forces.
The Practicability of Using Heavy Railway Artillery in the Coast Defenses of the United States.
Matériel in Possession of the Coast Artillery and Its Disposition.
The New Coast Artillery; Its Achievements and Its Possibilities.
Personnel Work in the Coast Artillery Corps.
The Future of Aircraft in the Coast Artillery.
Coast Railways for the Purpose of Defense.
Disposition of Ordnance and Ammunition on Hand.
Railroad Artillery as a Coast Defense Weapon.
Balloon Observation for Fire Control (Coast Artillery).
The Coast Artillery in Submarine Mine Defense.
The Barbette Howitzer for Coast Defense.
The Passing of the D. C.
Will Aerial Observation Supplant the Old System?
Mobile Coast Defense.

Coast Defenses of Charleston:

Probable Effect of the Great War Upon Our Coast Defense Matériel and Fire Control Methods.
An Ideal Organization for the United States Coast Artillery Corps Adaptable for Home Defenses or for Action Abroad.

Coast Defenses of Chesapeake Bay:

Mobile Armament for Defense and Its Relation to Fixed Armament.
Aerial Fire Control for Coast Defense.
A Scheme for Fire Direction of New Armament of the Heavy Mobile Type.
The Use in Coast Defense of Heavy Mobile Artillery.

Coast Defenses of Pensacola:

Railway Artillery for Seacoast Defense.
Lessons of the War as Applied to Heavy Artillery.
The Evolution of Heavy Artillery During the War.
The Pre-War Controversy as to the Relative Merits of Light and Heavy Artillery in the Light of Later Events.
The Human Element in the Service of Heavy Artillery in War.
Forecast of the Future for Heavy Artillery.
The Working of the Unit Supply System Within a Coast Defense.
The Similarity in Handling the Heavy Artillery to the Present Coast Artillery Methods With Arguments for Their Retention by the Coast Artillery.
The Advisability of Allowing the Navy the Operation of All Mine Defense.

Coast Defenses of Mobile:

Best Method of Operating Harbor Boats With Special Application to the Substitution of Enlisted Personnel for Present Civilian Crews.
Use of Anti-Aircraft Guns in Harbor and Coast Defense.
The Administration of a "Coast Defense," Duties to be Delegated to Fort Commanders, etc.
The Co-operation of the Navy With the Coast Defenses During Present and Future Wars.

Coast Defenses of New Orleans:

A Correspondence Course That Will Standardize Instruction and Insure All Officers Having Practical Knowledge of the Latest Methods Employed in the Use of Artillery.

Coast Defenses of the Potomac:

A System of Fire Control and Fire Direction Suitable Both to Coast Artillery and Heavy Artillery.
The Training of Coast Artillery Personnel as Modified by the Lessons of War.
The Organization and Administration of Coast (Heavy) Artillery as Modified by the Lessons of the War.

Coast Defenses of Boston:

The Relative Merits of Balloon and Aeroplane Observations.
The Duties of a Counter-Battery Officer.
Balloons Used as Base End Stations.
Factors Influencing the Selection of Tractor Artillery Emplacements.
Use of Railway Guns in Coast Defense.
Development of Wireless Telephone for Liaison Between Aeroplanes and Coast Defenses.

South Atlantic Coast Artillery District:

The Coast Artillery of the Future.
Railroad and Motorized Artillery in Coast Defense.
Coast Artillery in the Great War.
Lessons from the Dardanelles.
Submarine Mines, the Coast Artillery, and the Navy.
Calibers for Harbor Defense.
Organization of Coast Artillery Troops.

Coast Defenses of Los Angeles:

Esprit—The Advantage the Coast Artillery Should Reap from a Headquarters in Washington.
Is Not Regimental Organization Best, After All?
The Influence the Coast Artillery Should Have Upon Ordnance Construction.
Again—Co-operation Between Coast Artillery and Navy.
The Ideal Figure of Merit for Service Practice.
The Irreducible Minimum of Analysis of Results of Target Practice.
The Greatest Need of the Coast Artillery—Stabilization of Personnel in Assignment.
A Balanced Coast Defense—Fixed and Mobile.

The Great Essential—Simplicity of Method.
All Construction Work at Coast Artillery Posts to be Done by the Engineers.
What of Information Has the War Contributed to the Art of Coast Defense?
What Has the Coast Artillery Corps Learned from the War?
What Change in Coast Artillery Organization Should Be Made as a Result of the War?
What Change in Coast Defense Material Should be Made as a Result of the War?
What is the Present Range Limit of Fire Control in Coast Defense?
What is the Maximum Caliber that Should be Constructed Now for Coast Defense?
Closer Co-operation Between Navy and Coast Artillery Especially During Target Practice.
Changing Observing Interval or Changing Plotting System to Eliminate Errors of Predicting.
Proper Relation Between Heavy Mobile Artillery and Coast Defense.
Fire at Moving Railroad Trains.
Speed Versus Accuracy in Artillery Fire, All Cases, Showing the Desirability of Each According to the Particular Circumstances of the Case.
The Proper Factor of Safety in the Design of Field Guns.
Depression Range Finders for Use in Observation Balloons—Requisites Thereof.
Value of Resultant Probable Error of Guns and Range Finding.
Curved Line Prediction.
Mapping of Coast Railroads for Railroad Artillery.
Co-ordination of Fixed Defenses With Mobile Armament for Defense of Our Coast Line.
Relation of Coast Artillery With Our Naval Forces Renders Importance of the Former as Great as Latter: Through Efficiency of the Two Would Bring Safety With Small Mobile Army.
History of World War Shows Coast Defenses Still Impregnable.
With Our Navy and Coast Artillery at Top Notch of Efficiency, Size, and Preparedness, Could Any Attack on the U. S. Proper Hope to Succeed?

Coast Defenses of Cape Fear:

To What Extent Shall Railway Artillery Replace Guns on Fixed Mounts in Coast Defenses?
What Type of Gun Mount is Most Suited for Coast Defense Use?

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A "Five-Foot Shelf of Books"

In the post-war reorganization of the Army the Coast Artillery will undoubtedly keep in the regular service many ot the new officers who have contributed so much to the development of the Big Gun Corps in the war. These officers received the professional Coast Artillery training which they have depended on in their service so far under conditions of high tension, which aimed to hit only the absolutely indispensable bases of principle and high spots of practice.

Now that the rush is over, these officers will need and wish to reconsider their professional ground-work, with a view to re-establishing it firmly and broadly for their future work.

Before any officer can confidently undertake original work in his technical field, he must have *covered* the *ground* of his profession. In order to do this without groping or unnecessary repetition, his reading should be well-chosen so that he may get at accepted principles without having to wade through a mass of print of uncertain authority.

Consequently, right now something in the nature of a "Five-Foot Shelf of Books" for the Coast Artillery officer is in order. To be most useful, the list should be restricted to the essential subjects, and should represent the consensus of judgement of experienced officers of Coast Artillery. To meet this need, the suggestion is made that the readers of the JOURNAL who are experienced officers, take thought with themselves, and send to the JOURNAL their selection for such a shelf of books. Upon the receipt of these suggested lists, the JOURNAL will undertake to compile from them a true composite and present it for the use of the incoming generation of officers as a useful list from which to fill their first professional "Shelf of Books."

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Profiting by Experience

The JOURNAL is reprinting in this number, under Professional Notes, an article which originally appeared in the *Journal of the Royal United Service Institution.* This article gives an English viewpoint on the *Development of Mobile Artillery,* 1914-1918, and because of its clearness and thoroughness the discussion is reprinted in its entirety.

Editorial comment is warranted by the significance of so sharp and critical a summary of British experience in connection with the appraisal, which we are bound to undertake, of American artillery experience in the Great War. The formulation of correct judgements on the value and correctness of the details of our own experience is the necessary basis of our subsequent work. A comparison of British experience with our own is bound to be illuminating. For instance, in determining to what extent the Coast Artillery should follow up its natural preference for precision methods of fire, we are bound to weigh the value of less precise methods to meet particular conditions, and this consideration may well be influenced by an interpretation of Colonel Weber's statement that "fighting by eye to a large extent replaced fighting by the map." Again, his recurring reference to the changing rôle of trench mortars is pertinent to our problem. We recognize the problem of liaison and communication to be one calling for radical improvement. In this our experience certainly parallels that of the British artillery.

We will be wise to remember that all active participation of the American artillery in the Great War was limited to only a few of the phases of that great struggle, and comprised only one year out of the four, during all of which time the British artillery was absorbing experience, and operating under the widest variety of conditions. So we will do well to reinforce all of our own experience by that of those who were in the field so much longer than we.

From another standpoint this article is worthy of comment. By the very reason of its crisp summary of experience it suggests an idea we must firmly seize upon. The idea is this—all during the war artillery technique was constantly changing, and as fast as a method was put into effect, the scathing test of experience demanded the development of something new and better. Now, in the period of peace which is happily before us we will plan to rectify all the faults developed by our own experience in the war and as a result will evolve a beautifully complete and co-ordinated scheme, covering every element of artillery technique. Right then will we meet an insidious danger. In the absence of the bitter test of war, our completed product may look so good to us that we will not see its possible faults, and believing that we have reached the last word of artillery perfection, the temptation will come to settle back on our heels or even sit down, instead of keeping on our toes. If there is one more important lesson than another to be read from Colonel Weber's article, it is that no matter how necessary any procedure may be at a certain stage, it must inevitably be replaced by something newer and better. So let us guard against mental old age. At this time of reaction after the intense war-time concentration, it is very wise that every officer of the Coast Artillery should earnestly consider the necessity of keeping his mind youthful, elastic and "*on its toes.*"

PROFESSIONAL NOTES

The Development of Mobile Artillery, 1914-1918

By Lieut. Colonel W. H. F. Weber, C. M. G., D. S. O., R. F. A.

With a view to future policy, it may be of interest to examine the development of artillery during the last four years.

To borrow a simile from Robert Louis Stevenson, one should think of "the hand of a clock, which continues to advance as it indicates, rather than the stationary milestone, which is only the measure of what is past. Movement is not arrested."

The information at the writer's disposal is limited—dates given are perhaps inaccurate: nor is he in a position even to hint at the progress of gun construction and manufacture of munitions.

1870-1914

Prince Kraft's teaching contemplated the assembly at the earliest possible moment on the battlefield of the largest possible number of guns under the control of one brain—almost of one voice: this concentration was to knock out the opposing artillery and thenceforth to dominate the battlefield. His theory had to do entirely with tactics in a war of movement.

During the rest of the 19th century professional practice was directed chiefly towards the earlier arrival at effective fire by means of good fire discipline within the battery.

Here we come to the South African War.

The invention of facilities for indirect laying made it possible to bring artillery into action without previously exposing itself. Smokeless powder made it next to impossible to locate artillery thus concealed.

Quick-firing guns, if concealed, forbade opposing batteries to come into action, laying over the sights.

The Artillery Duel as known to Prince Kraft could no longer take place, because the opposing artilleries could not find one another.

Here comes the Russo-Japanese War.

The French improved the firing power of field artillery with their *soixante-quinze*, and by adding a shield strove to bluff away the hide-and-seek game and to "rush" success by direct fire from the hill tops. High explosive defeated the shield: back to indirect laying went the guns.

Here came the Balkan Wars of 1912.

It was now evident that aircraft would enable each side to locate the opposing artillery, and that this might re-introduce the artillery duel.

THE BRITISH ARTILLERY IN JULY, 1914

A well-known gunner, now occupying an exalted position in the Royal Regiment, described a certain school of artillery thought as having come over "on the crest of a French wave from Calais." According to the group of officers who formed this school, our methods were slow and our policy of training too conservative. They cried for more haste, closer support of the infantry (which was interpreted into actual proximity and a very short range in the final stages of each battle), direct laying, a more rapid rate of fire, less complicated gunnery, less telephone, more tactical teaching at our practice camps. The opposite school, afraid of being hurried into false training, pinned its faith to thorough instruction in gunnery: this school was certainly swimming against the current in 1914. "Field Artillery Training, 1914," chapter VII, was influenced from across the Channel, or at least was considered to be so by the Regiment at large.

The formation of "temporary groups," suggested in section 153, paragraph 6, was the subject of many discussions; the limitation to such grouping, i.e., "when those efforts cannot be directly combined," was somewhat freely interpreted, if not disregarded, at maneuvers.

It would be unfair today, in the light of our experience, to criticise the ideas expressed in "Field Artillery Training, 1914," for that manual was written solely on the basis of open warfare. It seems fair, however, to say that it showed a tendency to discountenance the principle of centralized control so ably set forth by Prince Kraft in his "Letters on Artillery."

The divisional artillery commander had been in existence as such only since early in 1908, and the officers holding the six billets had had little opportunity for practising control in the field. Under peculiar conditions of terrain, Colonel (now Lieut.-General Sir Lawrence) Parsons had given us an excellent demonstration at the relief of Ladysmith of what might be expected from a mass of guns under one man, but, generally speaking, the end of the South African War had brought the Regiment home opposed to the principle of centralized control: thenceforward all thought was directed towards the battle of encounter—where lack of time for preparation would necessitate decentralization.

One cannot shut one's eyes to the fact that previous to this war gunnery was insufficiently studied. The use of the map, in spite of the efforts of a few individuals ahead of their time, was discouraged at practice camps; the compass was seldom used; the effect of climatic conditions on explosives and on the trajectory of the shell was quite unknown to the average regimental officer. A serious effort to teach liaison had been made; Lieut.-Colonel (now Major-General Sir W.T.) Furse had amongst others come into prominence for his inculcation of training in forward observation officer's duties. The influence—the absolute indispensability—of communications, as we see them today, was scarcely dreamt of; strenous efforts on the part of various divisional artilleries to get things on a better basis met with the *non possumus* from the authorities.

A little elementary co-operation with aircraft had been carried out, and a good deal of discussion and writing had taken place as to the best methods of engaging aircraft with gun-fire. Concealment from the air *when in action* was rarely, if ever, mentioned within the writer's experience at our practice camps. Drill, turnout, and driving had reached a pitch that we could probably not attain today.

The need of re-armament of the field artillery with a new (truly quick-firing) gun was being constantly discussed, and may, for all the writer knows, have been actually initiated.

Lord Nicholson, then Chief of the General Staff, was commonly credited with hostility to the inclusion of heavy artillery in Great Britain's striking force. This may, or may not, be true, but, in any case, there existed the barest nucleus of what exists today.

NOVEMBER, 1914

The first two months of the war taught us to fear observation by hostile aircraft and brought about the beginning of artificial concealment. There was an immediate demand for anti-aircraft guns. The pom-pom arrived in September, the 13-pounder on a lorry-mounting in December, 1914. We learned, thus early, the need for the F.O.O. with a long telephone wire. No further experience was necessary to convince us that heavy artillery had come to stop (remain) as an essential feature of the modern battle.

WINTER, 1914-15—RE-APPEARANCE OF CONTROL

The end of the first battle of Ypres stabilized the battle. The proximity of the opposing infantry lines at once necessitated accuracy of fire, for which we were insufficiently trained; this went beyond the meticulous calculation of angles and touched upon the influence of climatic conditions. It was only want of practice due to lack of ammunition which prevented us from reaching much earlier the high standard of gunnery attained in later days. The flatness of the country forced upon both artilleries an exaggerated form of forward observation and a highly (too highly) organized system of liaison. It became necessary to keep the horses further back, to save casualties to horseflesh; that tended to divide the battery into the gun-line and wagon-line, while introducing the practice of dumping ammunition at the guns. Many of these tendencies re-adjusted themselves during the more open combats of later days, but not before the battle of Cambrai in November and December, 1917. What had come to stop was a new standard as regards the number of guns necessary in relation to number of rifles in the line.

1915. THE DEVELOPMENT OF CENTRALIZED CONTROL

By 1915 we had Army Artillery, as well as Corps Artillery, Commanders, whose powers became gradually but surely developed.

At Neuve Chapelle and Loos artillery movement was abortive, and the field artillery began to adopt siege methods. Fighting maps were introduced. Climatic conditions received continually increasing attention—the first instructions were issued in January, this year. H.E. began to complicate the sorting of ammunition, and the idiosyncracies of foreign-made shells necessitated much closer attention to the care and management of it.

A new responsibility fell upon the Field Artillery—wire cutting. Other developments:

(a) Trench mortars appeared.
(b) New divisions arrived with four-gun batteries.
(c) A new word—"camouflage"—sprang into existence.
(d) First use of gas (April 22nd).

(e) Arrival of "Mother" (9.2-inch howitzer) and "Granny" (15-inch howitzer).
(f) Appearance of balloons.
(g) Wagon-line changes. Increased use of lorries led to the abolition of brigade ammunition columns, and, later, reduction of divisional ammunition columns. Mules began to replace horses.

The whole tendency against mobility (and consequently in favor of centralization) was encouraged by the issue of carefully prepared defense schemes. The initiation of counter-battery work by the enemy brought into existence elaborate gun-pits: it became so difficult to move guns at night in and out of these pits that the custom sprang up of exchanging guns during a relief: there was much to be said against this. The call for large-caliber shells got ever louder.

1916

Early in the year the amount of heavy artillery had been greatly increased: it was organized in heavy artillery groups with a brigadier-general in command at corps headquarters working under G.O.C.R.A., Corps. The supply of ammunition was at last on a satisfactory basis.

Sound-ranging had started.

Trench mortars had by now been more logically organized: the new 3-inch Stokes remained with the infantry; the 2-inch and (about June) the 9.45-inch became attached to the divisional artillery under a Divisional Trench Mortar Officer, who, though perhaps not himself a gunner, generally formed part of the divisional artillery staff. Opinion varied as to whether trench mortars should be run by the general staff of the division or by the C.R.A. The one party argued that they were employed with, amongst, and against, infantry, and that it was always infantry who had to carry up their ammunition: therefore they should be run as a divisional (not divisional artillery) concern. The other party said that trench mortars provided an integral portion of the preliminary bombardment, and that they used the ordinary artillery methods of fire, therefore they should be part of the divisional artillery. Gradually this latter idea obtained the upper hand, chiefly because it was only when run by the artillery that they received proper consideration and supervision, but in everyday work, this system took the Field Artillery Brigade Commander out of his daily sphere of work.

Immediately before the battle of the Somme was witnessed a really big concentration of artillery: that behind Maricourt, where (owing to the shape of the line) the British and French artilleries were mixed up, was a most remarkable sight. The danger angle of our practice camp days was no longer considered.

The necessity of buried communications was now thoroughly appreciated, preparations being made accordingly.

The first meteor telegrams were issued in April, 1916.

It should be mentioned, that, early in the year, divisional schools had been established: divisional artillery schools were added, but were soon abandoned in favor of army artillery schools, amongst which that organized by Lieut.-General Sir A. E. F. Holland (G.O.C.R.A., Third Army) obtained notoriety.

It is here that we come to the battle of the Somme.

Early in the battle we had our first experience of gas-shells on a big scale, used by the enemy principally to interfere with our assembly.

The biggest development of the Somme was, however, the creeping barrage as we know it today. The idea was far from new: it had been attempted in South Africa, and was commonly practised by the French whenever they had the observation to do so. The enemy, finding he was losing all his machine-guns by our bombardment if he put them in his trenches, took to placing them in the open between trenches, so that our fire, lifting from trench to trench, missed them. To obviate this, the Field Artillery fire (xvth Corps, General Sir H. S. Horne) was directed so as to move forward just in front of the infantry with the purpose of annihilating every living thing opposing them. The new thing in this was that it was done by the map, the lifts being timed to suit the pace of the infantry advance, according as to whether the country was open or close, and the terrain rough or smooth. What was not foreseen was the high degree to which the idea developed. Limited at first to 18-pounders, it was later given depth by the addition of 4.5-inch howitzers, 6-inch howitzers, and even 9.2-inch howitzers. Not only was it used to protect the infantry during the advance, but actually to control their movement and the direction of that advance; for, if you must follow a thing, and it moves, you are no longer your own master. Eventually it became the main feature of the attack, so that the infantry could sometimes walk behind it with slung rifles, the only proviso being that they must be as close to it as possible, so that insufficient time should elapse after the barrage had passed an enemy hiding place to allow him to emerge and open rifle or machine-gun fire. The development of the creeping barrage, under favorable circumstances, and well practised by both field artillery *and infantry*, accounted for the capture of large numbers of prisoners in 1916 and 1917, and did much to knock out the famous "dug-out" system of defense—but the difficulties of preparation added a number of grey hairs to the British Artillery before it became a "drill." Very much more might be said on the subject: it is not, however, proposed to go into further detail here.

In some of the Somme episodes the ground gained was sufficient to entail movement on the part of the artillery. The difficulties of maintaining forward observation on the move were felt at once. Pigeons began to be used from observation posts, and even as early as this, wireless.

Portable camouflage nets became battery equipment after the Somme.

In the later stages the mud was so appalling that all ammunition had to be carried up on pack-saddles. No one who did not get personal experience can appreciate what drivers went through bringing up ammunition to the guns under such circumstances.

An important result of the experience gained on the Somme was the formation of Army Field Artillery brigades. Up to then, the divisional artillery had consisted of first four (three of 18-pounders and one of 4.5-inch howitzers) and then three (mixed) brigades. Batteries were nearly all four-gun batteries. It was found that, in order not to interfere with the artillery bombardment arrangements, a divisional artillery had to be left where it was in the line regardless of its infantry. In the later stage of the battle it was rare for a divisional artillery to cover its own infantrys. The infantry went in and came out: the gunners went in but came not out for many a week. To ensure the divisions being still formations of all arms in which infantry and artillery were accustomed to co-operate, one artillery brigade was taken away from each divisional artillery and made an army field artillery brigade: it was hoped in this way to ensure that a division could move complete in and out of the battle, while the higher artillery authorities obtained a reserve of field artillery at their immediate disposal. In combination with this change of organization batteries were increased to six guns each, largely in order to economize officers.

Stated generally, public opinion after the Somme was something as follows:

(a) It was recognized by the fighting soldiers at large that, instead of the artillery being called in to support the infantry where the latter wanted to attack, the infantry could attack whenever it was possible to employ a sufficient amount of artillery.

(b) The preliminary bombardment warned the enemy of attack: therefore that the true artillery battle must begin simultaneously with the infantry attack, i.e., at zero.

(c) Too much bombardment made such terrible havoc of the countryside that infantry could not recognize their objectives when they got them.

(d) Batteries became less parochial-minded in their choice of position; to quote Bairnsfather: "an 'old" was necessary—if it was a "better 'old," so much the better for the battery.

(e) Heavy artillery became recognized as the offensive branch of the regiment: counter-battery work became its principal duty: the field artillery in a war of position performed protective duties only.

(f) The field artillery, at any rate, could hope for little rest, in that it required the divisional artillery of two, three, or four divisions to cover the infantry of one.

(g) The Tank had made its debut, with all its immense possibilities for future traction of guns.

1917—To PASSCHENDAELE

Centralization continued to develop as a result of position warfare all through 1917 on the lines already indicated, until individuality was well nigh starved out of existence.

We got the recuperator for the 18-pounder, and the 6-inch Stokes trench mortar with its increased range.

The use of smoke by artillery was much developed.

Ammunition sorting was now becoming a great burden to the battery commander.

The indispensability of good communications to allow of so much centralization was marked by the transfer of R.A. signallers to the R.E., and the addition of a Signal Officer to each field artillery brigade staff.

In the heavy artillery a special Counter-Battery Staff Officer came into existence (July 1st, 1917), and sound-ranging was extensively developed: quite late in the year the R.G.A. was formed into permanent brigades instead of in constantly-changing heavy artillery groups. Heavy guns were included more and more in the creeping barrage, but there was no outward and visible sign yet that the Artillery was to be treated as *one arm:* the R.G.A. and R.F.A. were still kept well asunder.

We began to be considerably annoyed by enemy bombing, not only horse lines at night but even our gun positions.

The artillery suffered a great deal in the later stages of the battle of Arras from enemy counter-battery work. The terrible struggle for the Passchendaele Ridge followed; with such a mass of artillery for the enemy to fire at, with the impossibility of digging, with the harassing of the Flanders roads at night, and the new mustard gas, it is a matter for wonder that we carried on as we did—and, remember, we were already quite outranged by the German artillery. We came out a different regiment—interpret the phrase as you will.

1917—Battle of Cambrai

The Third Army attack in November, 1917, was remarkable for two things. In the first phase it was deemed necessary to procure surprise; the Germans had shown us how to do it at the Caporetto. The whole of the attacking artillery opened fire on the morning of November 20th without having fired a single registration round. Every gun had been calibrated in a back area (though not yet by the screen method), every position had been resected: positions were occupied only at the last possible moment. The surprise was complete.

In the second phase the Third Army was surprised by the German counter-attack on Gouzeaucourt on November 30th. In a few moments the whole elaborate system of control fell to pieces like a house of cards.

Unfortunately, only a small proportion of the regiment participated in this valuable experience.

1918—DECENTRALIZATION

The three German offensives in which the British artillery was engaged, followed by the great Entente counter, completed the teaching initiated at Cambrai. Decentralization occurred everywhere, though it hardly had time to affect the methods of employing heavy artillery: but even in this matter progress was seen, for a brigade of R.G.A. was affiliated early in the year to each divisional artillery. Control became limited to what the controlling authorities could arrange *before* the battle—allotment of guns to each front, and the barrage for each battle. The individuality of subordinate officers came again into play, more especially in the case of the field artillery brigade commander, to whose lot, if senior, fell the command of anything up to five brigades.

Our chief lessons from the German offensive were in the handling of guns in a big retreat. The preparations for it, as applied to the artillery, were tested to the ultimate degree—most of all the theory of "depth" and "silent" batteries. The mounted or dismounted orderly soon replaced the telephone wire: patrolling reappeared: the wagon-line became once more an integral part of the battery in action: the exaggerated form of liaison we were doing with each infantry battalion disappeared like the forward observation officer in the front line with two or three miles of wire behind him.

Heavy artillery battery commanders, when in difficulty, placed themselves at once under senior gunners on the spot.

When we, in our turn, attacked, the Regiment had regained its liberty. Barrages could never be dispensed with, but it was found possible to organize them on much simpler lines at the shortest possible notice: they were essentially "protective" in character. Rapid reconnaissance of positions was followed by rapid shooting-in: fighting by eye to a large extent replaced fighting by the map. To secure *surprise*, the preliminary bombardment of other days (and sometimes all registration) was dispensed with. The trench mortar died a welcome death: no wire was laid until it was seen to be necessary: even dumping was becoming a thing of the past. The armistice came before the process had reached a logical conclusion—which is a matter of regret, if one considers it from a point of view of training in the future.

The Future

Policy for the future is doubtless *sub-judice.* The writer only ventures to summarize certain features of our experience.

1. *Technical Training.*—Position warfare took up three years and four months out of four years and three months. We cannot afford to disregard the fact. Much of the annual practice must be devoted to purely gunnery problems, involving consideration of climatic conditions, and leaving movement out of consideration: it is only by ammunition that we can hope to learn. A *new* "Field Artillery Training" might contain a set of standing orders for a gun-pit as a guide to future battery commanders. Young officers should be specially trained in the duties of a forward observation officer—particularly as regards the signal service: they should be expert linesmen and have a working knowledge of all telephone instruments they are likely to deal with. They should be far more expert masters of all forms of equipment. The trench mortar service should not be left out of consideration.

2. *Tactical Training.*—It may be taken for granted that co-operation with aircraft and the engagement of aeroplanes will be commonly practised.

3. The work of artillery at maneuvers needs a very much higher degree of examination by expert umpires than has been the case in the past. Whether the battery can clear the crest, has had time and has tried to shoot itself in, whether communications are working, and whether the battery is well hidden, whether it showed itself before it opened fire, are points on which its efficiency vitally depends.

Maneuvers are troublesome things, because they are three parts dependent on imagination: the special tactical training a battery commander can get at maneuvers has been terribly neglected in the past in favor of the professional reputation he can snatch for himself and his battery at practice.

4. *Organization.*—The degree of control seems to depend on the amount of time available before battle is joined. Because, in times of position warfare so much could be done by the G.O.C.R.A., Corps, and because the divisional artillery was for certain definite reasons reduced—some people considered that the Divisional Artillery Commander (C.R.A.) had been "squeezed out." This does not appear to be the case, as became evident during the 1918 fighting. The Divisional Artillery could well be *increased.* It needs a C.R.A. more than ever, and must be trained with its infantry to ensure training in co-operation.

5. That part of the heavy artillery which is reasonably mobile ought to be part of the divisional artillery. It is beyond doubt that efficiency has been sacrificed through the existence of two regiments of artillery: it is not too much to say that the schism has at times been a laughing-stock to the infantry. It is one of the points which can easily, and ought to be, improved. Why not a Field Artillery "Group" consisting of the present field artillery brigade, one battery of 6-inch howitzers or 60-pounders, one trench mortar battery (formed on mobilization), and one group ammunition column? The heavy howitzers could be separately organized, and the purely coast defense guns be taken over by the Admiralty?

6. *Co-operation.*—Perhaps the most pressing need of all is to continue

to bring infantry officers into close touch with artillery methods. The whole management of artillery is an affair of communication. Many an artillery commander, in his fever to keep close alongside the infantry, has jeopardized his ability to control fire, only to find that at the last moment the infantry commander has changed his headquarters and rendered the artillery communication inoperative.

"Liaison" is a catch-phrase for the unwary; the very best liaison officer is not to be compared, for efficient co-operation, with the artillery commander himself.

Numerous pamphlets have been issued saying the two commanders must be together, and that the infantry commander must consider artillery needs. In practice the question of what accommodation there is, and ho comfortable, carries infinitely more weight. In the writer's humble opinion, "G" might take up this important question with more weight.

7. *Equipment.*—A battery needs at least five officers, even if a four-gun battery—but we have been well treated as regards numbers of officers. It needs a complement of all trades.

Most gunners whom the writer has met appear to like the four-gun organization best. It is greatly to be hoped that in the next war we shall have less complicated ammunition—and that we shall not be outranged.

Would it not be possible to save an immense amount of work by issuing harness with oxidized (or some other form of) metal work which could be *washed* clean?

Should Tank Traction be considered?

8. *Communications.*—The signal service is not yet sufficiently developed. It is the whole basis of control. If the R.E. is so much preferable to the R.A. signaller, it would be logical to extend the system to batteries.

The artillery brigade or group needs a dispatch rider service and arrangements for "wireless."

9. *Personnel.*—It is beyond hope that we can ever get a finer lot of officers and men than joined the Regiment when war broke out. It may be doubted if the whole annals of artillery contain anything better than the fortitude and endurance shown during Passchendaele, or than the gallantry displayed during the German offensive in 1918.—*Journal of the Royal United Service Institution.*

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A Method of Computing Differential Corrections for a Trajectory

By Gilbert Ames Bliss, Professor of Mathematics, University of Chicago.

In the following pages a method is explained for the computation of the corrections which must be applied to a trajectory to account for disturbances in the flight of a projectile of the magnitude of those caused, for example, by the wind. Its effectiveness depends upon a device which has been found useful in the computation of range tables by the methods of approximation which have been developed during the war. The details of the mathematics involved in the theory will be presented in a paper to be published with others of a similar sort in a supplement to this

Journal. In the exposition here given only those mathematical features are explained which seem indispensable to an understanding of the method.

The fundamental data for the computation of a range table for a specified gun, projectile, and powder charge, are obtained from firings by observing the muzzle velocity and the ranges corresponding to different angles of elevation of the gun. These observed ranges must first of all be corrected for variations from normal in the conditions under which the actual firings were made, for example for variations from normal in the temperature and weight of the powder charge, in the weight of the projectile, in the density of the air, and for wind. In the case of long ranges the curvature and rotation of the earth may also be taken into consideration. The accurate computation of the corrections requires a knowledge of the ballistic coefficient to be used in the expression for the retardation law. This value is also unknown at the start, and the corrections are first computed with the help of a ballistic coefficient which previous experience recommends as approximately correct. With the ranges reduced to normalized conditions obtained by making these approximate corrections, a new and sufficiently accurate value of the ballistic coefficient may be obtained, and the range elevation table with its accompanying differential corrections may then be found in its final form by actual computation of one form or another based upon the differential equations of the trajectory.

For flat fire the classical method for finding the differential corrections mentioned in the preceding paragraph is by means of the formulas of the Siacci theory and the Ingalls tables. This method has been exceedingly well organized and is most convenient, but it involves the well-known Siacci approximation which unfortunately can not be justified for higher elevations, though it is a most convenient and helpful device within its range of applicability. So far no scheme applicable for all elevations and analagous to the Siacci-Ingalls theory, by means of which range tables for use in the field can be computed from tabulated data such as appear in the Ingalls tables, has been established in practise, though it is within the range of possibility that such a method can be devised on the basis of the newer theories which have been evolved during the past five years.

In the Siacci-Ingalls theory the reduction in the retardation of the projectile due to the rarification of the air at higher altitudes is accounted for by introducing a so-called altitude factor in the ballistic coefficient. This is not a particularly happy device, and it has been avoided by Major F. R. Moulton, who seems to have been the first to have frankly introduced into the expression for the retardation law itself a factor which suitably reduces the retardation as the altitude increases. The formula for the retardation adopted by Major Moulton is

$$R = \frac{vG(v)\ H(y),}{C}$$

where $vG(v)$ is the retardation, expressed in terms of the velocity v, of a standard projectile moving through air at normal sea level density, where C is the ballistic coefficient which enables this expression for the retardation to be adapted to projectiles of other types, and where $H(y)$ is a factor which is unity when the altitude y is zero and which decreases as observation has shown that the density of the air normally decreases when the altitude y increases. The differential equations of the motion of the projectile then turn out to be:

$$(1) \qquad x'' = -\frac{1}{C} G(v)\, H(y)\, x', = -Fx'$$

$$y'' = -\frac{1}{C} G(v)\, H(y)\, y' - g = -Fy' - g,$$

where x′, x″, y′, y″ are the derivatives with respect to the time t of the coordinates x, y of the projectile, and F is merely a convenient symbol for the expression GH/C.

The crucial functions in the differential equations which have just been set down are the functions G and H. The values of the former have been tabulated from the results of experimental firings and the table has been smoothed with the help of an analytic function which fits it with sufficient accuracy. Several expressions have been given for H (y), among which is the well-known Hamilton law of atmospheric density. For actual computation, however, it turns out that H(y) can be more conveniently expressed in the form of an exponential e^{-ay} where a is a suitably chosen small positive constant. From the standpoint of accuracy it makes little difference which form for the altitude function H is used, provided only that proper corrections are applied to account for the variations from the chosen norm in the density of the air at the time when a particular shot is fired.

The differential equations (1) so established can not be integrated in the usual way by means of known functions, but their solutions can be found by methods of approximation. The trajectory whose form is characterized by them is the one along which the projectile will fly when all conditions are normal. It is not proposed to discuss here the methods by which this normal trajectory is computed. The forms for the computation have been skillfully arranged by Major Moulton and his associates so that the work proceeds with rapidity and accuracy. The purpose of the writer is rather to present methods of computing the differential corrections to the trajectory which, when used in conjunction with Major Moulton's theory, make the labor of computing a range table not excessively greater than that required in the Siacci-Ingalls theory. The new methods have further the great advantage of being applicable with equal degrees of accuracy for all angles of elevation.

Suppose then that a trajectory has been computed as a solution of the equations (1). The actual flight will be in a slightly different path when a wind is blowing or when the density of the air or the initial conditions of velocity or elevation are not normal. The velocity and the direction of the wind at different altitudes can be found as usual by observing a pilot balloon at the time of firing, and the magnitude of the following wind component so determined will hereafter be designated by w (y).There will also be a cross wind effect which can be determined separately, and which for the sake of simplicity will not be considered here. The air density at different altitudes at the time of firing is determined from airplane observations of temperatures and pressures, so that the density function H+δH which should be introduced in place of H in the equations (1), to account for any irregularities in the densities of the day at different altitudes, can be regarded as known. The equations of the disturbed trajectory then have the form

$$(2) \qquad \begin{aligned} \dot{x}'' &= -(F+\delta F)\ (\bar{x}' - w(y), \\ \bar{y}'' &= -(F+\delta F)\ \bar{y}' - g, \end{aligned}$$

ξ

where $\bar{x} = x+\epsilon$, $\bar{y} = y+\eta$ are the coordinates of the projectile on the new trajectory, and δF is the correction to be added to F to account for both the wind and the altered density. The values of ξ and η are clearly the corrections which must be added to the coordinates x and y of the projectile at a point on the undisturbed trajectory in order to obtain the position $\bar{x}$, $\bar{y}$, of the projectile on the disturbed trajectory at the same time t. The details of the mathematical justification for these equations, as for a number of those which follow, are omitted. For the present it is sufficient merely to note them down, so that the meaning of the differential equations about to be deduced for ξ and η may be clear.

When the equations (1) are subtracted from equations (2) two new equations for ξ and η are found. If terms of the second order in the small quantities $(\xi'-w)/v, \eta'/v$ are neglected these new equations take the form:

$$(3) \quad \xi'' = x'F\left(ay-\frac{\delta H}{H}\right) - F\left(1+x'^2\frac{G'}{vG}\right)(\xi'-w) - x'y'F\frac{G}{vG}y',$$

$$y'' = y'F\left(ay-\frac{\delta H}{H}\right) - x'y'F\frac{G'}{vG}(\xi'-w) - F\left(1+y'^2\frac{G'}{vG}\right)y',$$

where a is the constant in the function $H = e^{-ay}$. Ordinarily these equations would have to be integrated repeatedly to get the values of ξ and η for the different types of corrections desired. This is rather a laborious process, however, when methods of approximation have to be used, and it is the purpose of this paper to show how the desired data may be obtained by integrating a single time, instead of many times, a second system of differential equations called the system adjoint to the system (3).

Let ω be the positive angle of fall at the end of the undisturbed trajectory for which the time of flight will be represented by T. Then at the time T the projectile on the disturbed trajectory will have coordinates $(x+\xi, \eta)$, and the difference ΔX of the two ranges has the value

$$\Delta X = [\xi + \eta \cot \omega]_{t=T},$$

as is readily seen from the figure. The quantity ΔX is the one whose value is desired.

The system of equations

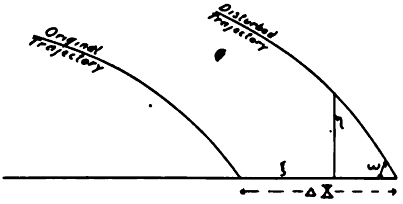

Fig. 1.

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$$\mu' = -aF(x'\checkmark+y'\varrho),$$

$$(4) \quad \checkmark' = -1+F\left(1+x'^2\frac{G}{vG}\right)\checkmark + x'y'F\frac{G'}{vG}\varrho,$$

$$\varrho' = -\mu+x'y'F\frac{G'}{vG}+F\checkmark\left(1+y'^2\frac{G}{vG}\right)\varrho,$$

where μ, $\checkmark$, ϱ are three new auxiliary variables, is called the system adjoint to the equations (3). These equations may be integrated for μ, $\checkmark$, ϱ

with initial values $\mu - \cot \omega = \surd = \varrho = 0$. at the time T at the end of the trajectory. When the equations (3) are multiplied, respectively, by $\surd$ and c and added, it is found after some manipulations with the help of equations (4.), which will not be explained in detail here, that

$$\frac{d}{dt}\,(\xi + \mu y + \surd\,\xi' + \delta y') = (\surd' + 1)\,w + \frac{\mu'}{a}\frac{\delta H}{H}$$

The integration of this equation from 0 to T gives

$$\Big[\ \xi + \eta \cot \omega\ \Big]^{t=T} - \Big[\surd\xi' + \varrho\eta'\Big]^{t=o}$$
$$= \int_0^T (\surd' + 1) w dt \ + \frac{1}{a}\int_0^T \mu' \frac{\delta H}{H}\ dt,$$

since $\mu - \cot \omega = \surd = \varrho = 0$ at $t = T$, and since the two trajectories have the same starting point so that $\xi = \eta = 0$ at $t = 0$. Hence the value of ΔX is given by the formula

(5)

$$\Delta X = \Big[\surd\xi' + \varrho\eta'\Big]\ t = o + \int_0^T (\surd' + 1) w dt + \frac{1}{a}\int_0^T \mu' \ \frac{\delta H}{H}\ dt.$$

The formula (5) just derived is the basis of the computations of the differential corrections. Everything in it is completely determined when the solutions μ, $\surd$, ϱ of the equations (4) are known. If the corrections for altered initial conditions, wind, and density are considered independently of each other, it gives the three formulas

$$\Delta X = \ [\surd\ \xi' + \varrho\eta']^{\,t=0},$$
$$(6) \qquad \Delta X = 10\ \ [t_2 - t_1 + \surd(t_2) - \surd(t_1)\ ],$$
$$\Delta X = \ \frac{.01}{a}\ \ [\mu(t_2) - \mu(t_1)\ \ ],$$

respectively, for the range corrections due to changed initial conditions, to a 10 m/s wind blowing from a time t_1 to a time t_2, and to a one per cent variation from normal in the density of the air ($\delta H/H = .01$) on the part of the trajectory traversed between the times t_1 and t_2.

The results described above may be summarized as follows. Suppose that a trajectory for a projectile traveling under normal conditions has been found from equations (1) by a method of approximate integration. Then in order to find the corrections to the range of the projectile which must be made to account for wind or for abnormal initial conditions and air-density, it is necessary to integrate the equations (4) once, by approximate methods, for the three auxiliary functions μ, $\surd$, ϱ, with initial conditions $\mu - \cot \omega = \surd = \varrho = o$ at the time $t = T$ at the end of the trajectory. The required corrections may then be calculated from the formulas (6) by the elementary operations of arithmetic. This process replaces the repeated integrations for the differential corrections which must be made if the equations (3) are used directly. The mathematical argument which justifies the method here explained is perhaps somewhat complicated, but it needs to be made but once, and it leads to simple formulas which save much labor in the actual computations.

The corrections for cross wind and the rotation of the earth, and a method of solving the more complicated problem of the corrections for anti-aircraft firings, may be deduced by similar considerations. These are, however, beyond the scope of the present paper, and will be described in the articles mentioned in the first paragraph above.

✤ ✤ ✤

Experimental Firing of 12-inch R. R. Gun, Model 1918.

The pilot mount of the 12-inch railway gun, model 1918 (Battignoles), was fired for the first time at Aberdeen on May 6, 1919. The carriage mounts a 12-inch gun, model 1895. The elevation of this gun is from minus 5 to plus 38 degrees, giving a range, with the 900 pound projectile, of about 30,000 yards. The traverse permitted by this gun is 5 degrees each side of the direction in which the track is laid. For firing, this mount requires a structural steel platform which is carried on a ground platform car, and for each mount there are two separate platforms, thus facilitating the transferring of the mount from one position to another. This ground platform is laid down in six sections over which the mount is run and the weight removed from the trucks of the car by means of wedges placed between the ground platform and the car body.

This is the first of 12 of these mounts that are under manufacture and will be completed.

In firing this gun at this time no defects were noted. Further test and experiment will be carried on in order to determine if there are any that will be likely to develop. This gun is loaded by the gravity method, that is, the projectile is allowed to slide down an inclined tray leading into the breech of the gun.

This mount was placed in position and fired by the company of Coast Artillery, under the command of Captain W. F. Ayres, C. A., which is stationed at Aberdeen Proving Ground, Aberdeen, Maryland.

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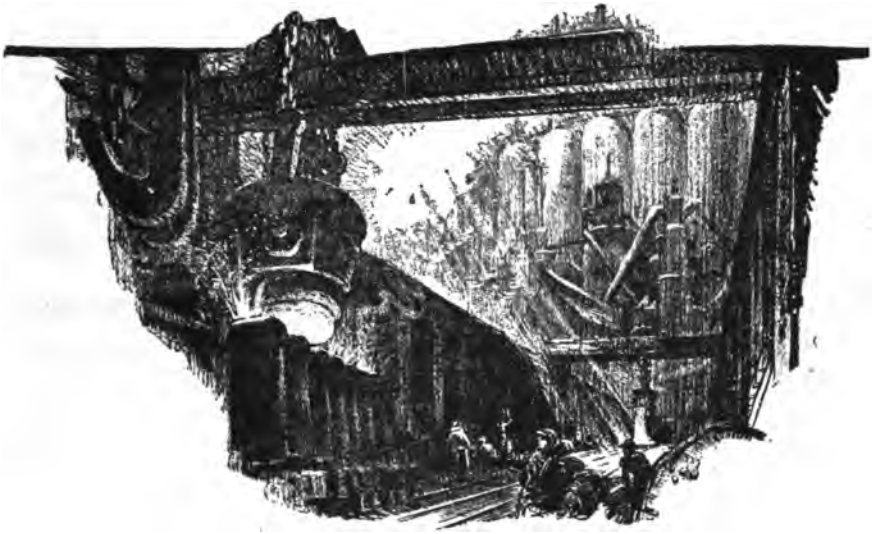

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